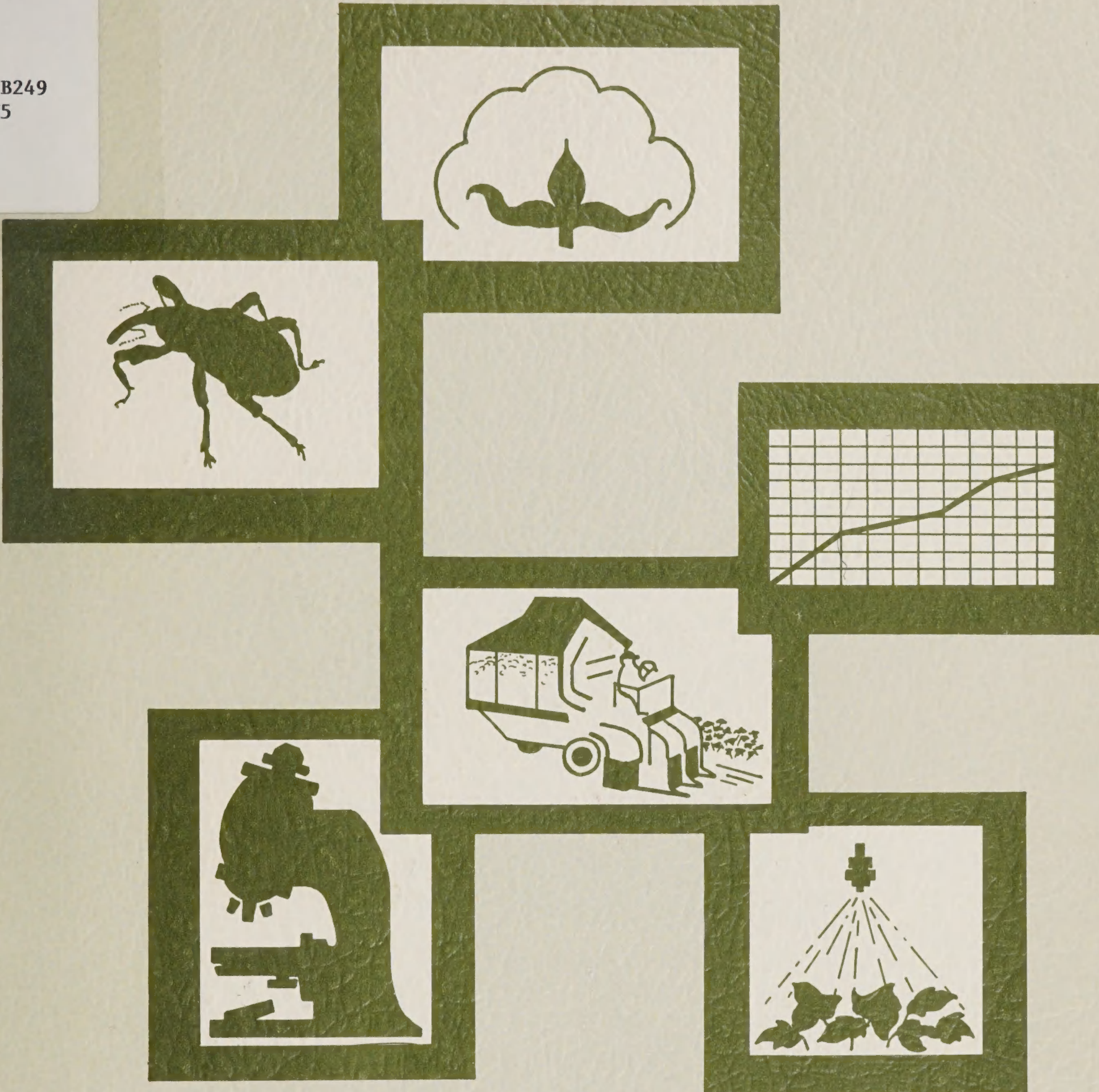

The 1979 National Cotton Research Task Force Report

THE 1979 NATIONAL COTTON RESEARCH
TASK FORCE REPORT

TABLE OF CONTENTS

TABLE OF CONTENTS

SUMMARY AND HIGHLIGHTED RESEARCH NEEDS

The Task Force identified nine major research needs for cotton (not listed in any order of priority):

1. Improved biological efficiency of the cotton plant.

2. Improved plant response to environmental stress.

3. More effective and efficient pest control.

4. Improved fiber quality, processing efficiency, and consumer textile products.

5. Improved seed quality, processing efficiency, and consumer products.

6. Economic analysis of the cotton industry and improved effectiveness and efficiency in marketing.

7. More effective conservation of energy, soil, water, and chemicals used in production and processing.

8. Reduced environmental pollution during production and processing.

9. Protection of man from harmful effects of pollution, toxic contaminants, and natural toxins associated with production, processing, and end use.

Each of these areas was reviewed by a subcommittee and a report prepared. Detailed analyses of their findings and recommendations are presented in subsequent sections. Subcommittee chairmen met with consultants representing industry and research administrators to review and discuss the individual subcommittee recommendations. This group, acting as a "Committee of the Whole," then attempted to objectively assess overall needs and priorities. Their recommendations are:

1. The disciplines and research groups that serve cotton are interrelated and interdependent. A balance among the various disciplines and research activities must be maintained. This includes a balance between the basic and applied approaches. For a healthy cotton industry research in specific areas cannot be turned on and off like a water spigot if that area is to remain effective. A core of stable research must be maintained to meet continuing needs throughout the industry. At the same time, crucial problems may arise which must be immediately researched. Although some resources may be redirected to this emergency research, additional funding may be necessary to meet research users' needs. Cotton dust is a current case in point.

2. We must develop new systems, or improve current systems, to produce and process cotton and cottonseed more efficiently. In addition to maintaining a stable core of research in all of the nine areas cited above, the Task Force feels the following research objectives are critical to meet cotton's needs over the next five to ten years:

   a. Elimination of the causative agents of byssinosis and control of cotton dust.

   b. Improved understanding of the physiological/biochemical processes in the cotton plant which regulate seed germination, vegetative growth, fruiting and growth termination. New knowledge of these basic processes is needed to accelerate progress in breeding and to develop more precise and dependable plant and crop management systems.

   c. Improved tolerance of the cotton plant to water stress and increased efficiency of water use in producing cotton.

   d. Improved plant resistance to multiple pests (diseases, nematodes, and insects) with special emphasis on new sources of resistance to insects.

   e. More effective and efficient weed and insect control, harvesting, ginning, and fiber processing techniques to reduce costs, increase returns, conserve energy, and maintain the inherent quality of the lint and seed.

   f. Improved cultural, tillage, and pest management practices for reducing runoff to minimize soil erosion and contamination of waterways.

   g. Production of cottonseed free from chemical contamination and toxins and with improved quality for food and feed.

   Specific research approaches with suggested priorities and the recommended resources needed to accomplish the above objectives are described in detail in subsequent sections.

3. This Task Force was appointed to assess research needs. However, we emphasize a very important need to improve and accelerate technology transfer from researchers to the users. This should involve research leaders, extension specialists, and user groups in jointly organized "pilot tests," research validation trials," "on-farm or in-plant trials and demonstrations," and other imaginative approaches to accomplishing this objective. We urge that administrators take specific steps to implement these activities.

4. Research and education resources are limited and the public and private research sectors need to coordinate efforts to avoid duplication and insure complementarity. Generally, longer range, more basic research can be more effectively conducted by the public sector. Developmental efforts, on the other hand, can often be better met by private industry. The USDA is organized to conduct research applicable to broad regional and national needs, whereas the State Experiment Stations may have a better understanding of local needs unique to their area, although they are supportive of each other. Situations, capabilities, and resources vary greatly, however, and the continuing interchange among all groups fostered by the annual Beltwide Cotton Production and Research Conferences is essential to plan and implement the most efficient use of total resources.

COTTON - A RENEWABLE NATIONAL RESOURCE

Cotton is a renewable national resource providing fiber for textiles, feed for livestock, and vegetable oil and protein for human consumption. Production, average yield, and farm values for selected years are presented in Table 1. As is evident from these data, cotton is not a crop of diminishing importance in the United States. Production has been remarkably stable since 1920. Farm value approximated $4 billion in 1977, with an estimated retail value of more than $40 billion. Current projected export for this season is 6 million bales, which is a very significant factor in the nation's balance of trade. World consumption has risen from 17.2 million bales in 1920 to an estimated 60.5 million bales in 1977. Although man-made fibers have made up an increasing proportion of total fiber consumption over this period, increased population and increased per capita consumption have maintained a relatively steady demand for U.S.-produced cotton.

Considering that cotton is a renewable national resource, as contrasted with the petroleum based synthetic fibers, it appears that domestic and foreign demand will actually increase in the future. In a detailed analysis entitled, "Cotton and the Energy Crises: What Does the Future Hold?" (published in Oil Mill Gazetteer, August 1974), Carter and Kopacz concluded that "based on our limited knowledge of the present energy crises--we would suggest that prospects for increased usage of cotton and cottonseed products is indeed bright."

Yield per acre has increased three-fold since 1920--or to put it another way, we are now meeting our cotton needs by planting only one-third as many acres as we were 50 years ago. This very significant increase in production efficiency is based to a large extent on our past research. Continued research will be essential, however, to maintain and improve production and processing efficiency and to provide the consumer with safe and high quality products.

The National Academy of Sciences, in a report entitled "Fibers as Renewable Resources for Industrial Materials," published in Washington, D.C. in 1976, concluded that industries based upon fibers from renewable resources are among the most important in the nation. They estimated that research expenditures for 1972 by the Cotton Industry (public and private) approximated $40 million for production and marketing. They recommended that research funding for cotton should be increased by at least 50% with appropriate adjustments for inflation.

Public research support, FY 1977, for cotton and other major crop commodities and their estimated farm and retail value are summarized in Table 2. In terms of scientist years per billion dollars of retail value, support for cotton research is modest as compared with other major crops.

Table 1. Cotton production, average yield, and farm value for selected years (USDA, Economic and Statistical Research Service, Washington, D.C.).

Year	Production (bales)	Average Yield[1/] (lbs/A)	Farm Value of Lint and Seed (1,000 dollars)
1920	13,429	160	1,219,806
1930	13,932	174	792,035
1940	12,566	246	736,127
1950	10,014	282	2,360,277
1960	14,237	454	2,404,142
1970	10,192	464	1,351,229
1975	8,302	494	2,355,942
1976	10,581	465[2/]	3,683,131
1977	14,496	520[2/]	4,002,973

1/ 5-year centered average yield.

2/ Actual yield.

Table 2. Research support (from the Current Research Information System) in Fiscal Year 1977 by USDA, SAES, Forestry Schools, and other public institutions for cotton and other major crop commodities compared to their estimated farm and retail value.

Crop	Research Support: Funds (Thousands)	Research Support: (Scientist Years (SY's)	Crop Value: Farm 1/ (Billions)	Crop Value: Estimated Retail 2/ (Billions)	SY's per Billion Dollars of Value: Farm	SY's per Billion Dollars of Value: Retail
Cotton and cottonseed	$38,388	436.0	$ 3.96	$41.30	110.4	10.6
Corn grain	24,852	301.8	12.89	35.90	23.4	8.4
Rice	5,247	66.6	0.94	4.63	70.9	14.4
Sorghum grain	6,516	82.6	1.36	2.86	60.7	28.9
Soybeans	26,956	324.2	9.94	26.30	32.6	12.3
Sugarcane and sugarbeet	9,827	110.1	0.99	2.40	111.2	45.9
Wheat	21,292	268.1	4.68	17.50	57.3	15.3

1/ Agricultural Statistics 1978, USDA. (Crop year 1977)

2/ See Appendix to Table 2 for basis of estimates computed by the Economic and Market Research Department, National Cotton Council of America, April 30, 1979.

Appendix to Table 2

Retail Value of Selected Crops

Corn	Oct. - Sept., 1976-77	$35.9 billion
Grain Sorghum	Oct. - Sept., 1976-77	2.86 billion
Soybeans	Sept. - Aug., 1976-77	26.3 billion
Wheat	June - May, 1976-77	17.5 billion
Rice	Aug. - July, 1976-77	4.63 billion
Sugarbeet & Sugarcane	Calendar 1977	2.4 billion
Cotton & Cottonseed	Average*, 1976-77 & 1977-78 (Aug. - July)	41.3 billion

The following general procedure was used to estimate the retail value of selected crops:

1. Crop production during the 1976-77 crop season was determined.

2. Major uses of the crop, including the resulting retail products, were determined.

3. If the crop was used directly as a retail product (e.g., canned corn), an appropriate average retail price for the retail product was estimated. This price was then multiplied times the supply of the crop available for use in this product. The resulting number was the estimated retail value.

4. If the crop was not used directly as a retail product, but instead was a "part" of another retail product (e.g., corn fed to dairy cows is partly responsible for the milk produced by the cow), then it was first necessary to estimate the retail value of the product (e.g., milk). A portion of that total retail value was then allocated to the crop (e.g., corn). This allocation was the retail value of the crop.

5. In some cases, crops were used in more than one retail product. In these cases, the crop was allocated among the various uses. Retail values for each use were estimated and added together to approximate the total retail value of the crop.

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*Average production for 1976-77 and 1977-78 was used since the 1976-77 crop was exceptionally small, and the 1977-78 crop was very large. The average of the two crops is more representative of a "typical" crop.

ORGANIZATION AND PROCEDURES

The 1973 Task Force expressed concern that the requirement to organize their report in Research Problem Areas (RPA) restricted documentation of multidisciplinary teamwork. Consequently, we decided to organize the current review around major research needs with each subcommittee composed of scientists from various appropriate disciplines to consider resources and approaches for solving those needs. We identified the following nine major research needs:

1. Improved biological efficiency of the cotton plant.

2. Improved plant response to environmental stress.

3. More effective and efficient pest control.

4. Improved fiber quality, processing efficiency, and consumer textile products.

5. Improved seed quality, processing efficiency, and consumer products.

6. Improved effectiveness and efficiency in marketing.

7. More effective conservation of energy, soil, water, and chemicals in production and processing.

8. Reduced environmental pollution during production and processing.

9. Protection of man from harmful effects of pollution, toxic contaminants, and natural toxins associated with production, processing and end use.

Bench and field scientists representing appropriate disciplines, geographical areas, and federal, state, and industry interests were selected to make up each subcommittee.

Within their assigned area each subcommittee reviewed all of the current CRIS project reports, assessed future needs, identified priority objectives, and recommended research approaches and the resources needed to solve the identified problems. After preparing individual subcommittee reports, committee co-chairmen met as a "Committee of the Whole" to assess overall needs and priorities. Consultants, representing administrators and directors of various public and private groups, met with the subcommittees and the "Overall Task Force Committee" and provided very valuable input. A listing of the membership of the review committees follows this section.

Assignments of current research projects to the subcommittees for review and delineation of responsibility for considering future research needs were somewhat arbitrary in many cases. This also resulted in some duplication of recommendations for research in certain areas. Nevertheless, we felt the advantages of the multidisciplinary approach outweighed these classification and accounting problems.

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SUMMARY TABLES

Four tables summarizing past, current, and recommended distribution of resources for cotton research are presented here for reference.

Table 3. Summary of activity by research problem areas documented in the Current Research Information System for Fiscal Years 1972 and 1977.

During this five year period total funding for cotton research increased from $29.5 million to $38.4 million. However, Scientist Years decreased during the same period from 492.3 to 436.0. Major shifts in Scientist Years were an increase in the health and safety area (from 0.1 to 46.7) and a decrease in the development of new and improved feed, textile, and industrial products.

Table 4. Summary of current (fiscal year 1977) funding and scientist years (SY's) for the nine major research activities.

The subcommittee reviewed all current (FY 1977) CRIS project reports and estimated the percentage of funding and SY's associated with each of the indicated nine major areas. Classification was somewhat arbitrary in certain cases. The FY 1977 reports were the latest ones available for review by the subcommittees in the spring of 1979.

Table 5. Summary of current and recommended scientist years (SY's) for research objectives within each of the nine major research activities.

Each subcommittee identified major research objectives within each of the nine broad research activities. For each of the objectives, subcommittees estimated current (spring 1979) SY effort and then recommended the distribution or redistribution of SY's among the objectives <u>within</u> an activity assuming 1) no increase in funding resources except for adjustment for inflation, 2) a 20 percent increase in funding resources after adjustment for inflation, and 3) no limitations on resources. Please note that the assumptions refer to funding resources although the recommendations are given in SY's. Thus, under the assumption of no change in funding resources, subcommittees could recommend decreased SY's with an implied increased funding per SY. Also note that the estimated current SY effort was the subcommittees' best estimate for 1979, and thus the numbers may vary from the latest available CRIS data which are for FY 1977.

The right hand column of Table 5 indicates the relative priority assigned by the subcommittee to each research objective within that major problem area. Detailed analyses and justifications for the recommendations in each of the nine major activities are presented in the respective sections of the main body of the report.

Table 6. Summary of current and recommended scientist years (SY's) for each research problem area (RPA) concerning cotton within the CRIS classification system.

Table 5 is based on the classification of research into the nine major research activities used for the current study. Table 6 summarizes the same data but uses the Research Problem Area (RPA) classification which is regularly used in CRIS and which was used in earlier reports. This permits direct comparisons and "tracking" with earlier studies.

Table 3. Summary of activity by research problem areas documented in the Current Research Information System for fiscal years 1972 and 1977.

Number	Research Problem Area Title	Funding ($1000) 1972	Funding ($1000) 1977	Scientist Years 1972	Scientist Years 1977
105	Conserv. use of water	-	44.6	-	0.5
109	Weather adapt. & mod.	-	8.2	-	0.1
207	Control of insects	7,715.4	11,299.9	102.3	109.7
208	Control of diseases	2,450.5	2,872.7	41.2	37.9
209	Control of weeds	839.1	1,155.2	17.2	14.6
214	Protection from pollution	375.2	162.0	6.6	1.2
307	Improve biological efficiency	4,635.7	7,075.0	83.0	68.5
308	Mechanization of production	2,307.2	2,511.4	35.6	24.3
309	Production management systems	524.8	613.8	9.8	7.1
405	Production for improved acceptability	984.0	1,269.6	16.0	16.6
406	New and improved food	1,011.4	1,347.9	16.8	19.3
407	New and improved feed, textile, and industrial products	6,124.0	3,778.1	120.0	51.5
408	Quality maintenance in storage and marketing	148.6	175.6	3.5	1.9
501	Improved grades and standards	914.4	890.6	11.5	7.8
503	Marketing efficiency	486.5	203.5	12.6	4.4
506	Supply, demand, and pricing	222.4	510.4	3.1	8.0
507	Competitive relationships	1.5	17.6	0.0	0.4
508	Domestic market development	147.7	-	1.9	-
509	Performance of marketing systems	4.4	378.4	0.1	6.4
601	Foreign market development	13.2	24.3	0.2	0.3
604	Produce development for foreign markets	1.5	-	0.1	-
701	Food products free of toxic contaminants	0.9	-	0.0	-
702	Protect food and feed from toxins	565.8	513.3	10.3	6.1
704	Home and commercial food service	4.8	-	0.1	-
708	Human nutrition	-	82.7	-	1.0
709	Reduce hazards to health and safety	1.4	3,195.2	0.1	46.7
808	Government programs to balance output and demand	1.9	-	0.1	-
901	Alleviate pollution	39.7	258.0	0.3	2.0
	Total	29,521.9	38,388.2	492.3	436.0

Table 4. Summary of current (fiscal year 1977) funding and scientist years (SY's) for the nine major research activities

Activity	Funding	SY's
Biological Efficiency	$ 5,021,267	62.3
Environmental Stress	2,615,451	13.9
Pest Control	15,602,126	164.6 1/
(Biological Control)	(9,001,978)	(85.6)
(Chemical Control)	(2,936,193)	(34.9)
(Host Plant Resistance)	(3,663,955)	(44.1)
Fiber Quality, Processing and End Use	5,802,952	68.7
Seed Quality, Processing and End Use	1,896,589	25.1
Marketing and Economic Analysis	1,561,934	24.4
Resource Conservation	1,424,453	14.9
(Energy)	(718,967)	(7.3)
(Soil and Water)	(255,902)	(2.4)
(Chemicals)	(449,584)	(5.2)
Environmental Quality	469,358	5.2
Health and Safety	3,994,111	56.8
Total	$38,388,241	435.9

1/ From Table 3, these SY's may be subdivided by class of pest:

Insects	109.7 SY's
Diseases	37.9 SY's
Weeds	14.6 SY's

Table 5. Summary of current and recommended scientist years (SY's) for research objectives within each of the nine major research activities.

Research Activity	Level of SY Effort: Current[1/]	No Increase[2/]	20% Increase	Recommended	Priority Within Activity
Biological Efficiency:					
A. Basic Research on Physiological/Biochemical Processes	13.4	21.8	26.1	28.3	1
B. Production Practices for Increasing Yield	13.1	19.2	23.0	25.0	3
C. Development of Superior Germplasm	36.5	22.0	26.4	28.6	2
Total	63.0	63.0	75.5	81.9	
Environmental Stress:					
A. Plant Water Stress	5.6	4.0	4.8	8.5	1
B. Chilling Stress	2.6	1.7	2.2	6.0	2
C. Mineral Stress and Fertilizer Efficiency	0.9	1.3	1.6	5.0	3
D. High Temperature Stress	1.3	1.3	1.9	2.5	4
E. Increase Production on Salt-Affected Soils	0.1	0.1	0.1	3.0	5
Total	10.5	8.4	10.6	25.0	

Table 5 continued

Research Activity	Level of SY Effort: Current[1/]	No Increase[2/]	20% Increase	Recommended	Priority Within Activity
Pest Control					
A. Biological Control					2
Insects	71.1	71.1	85.3	78.1	
Diseases/ Nematodes	11.4	11.4	13.9	14.4	
Weeds	3.5	3.5	4.3	5.5	
Subtotal	86.0	86.0	103.5	98.0	
B. Chemical Control					3
Insects	14.4	14.4	17.3	19.5	
Diseases/ Nematodes	8.6	8.6	10.3	11.2	
Weeds	5.7	5.7	6.8	12.2	
Subtotal	28.7	28.7	34.4	42.9	
C. Plant Resistance					1
Insects	18.9	18.9	22.7	27.7	
Diseases/ Nematodes	23.3	23.3	28.0	33.0	
Weeds	0	0	0.1	0.5	
Subtotal	42.2	42.2	50.8	61.2	
Total:					
Insects	104.4	104.4	125.3	125.3	
Diseases/ Nematodes	43.3	43.3	52.2	58.6	
Weeds	9.2	9.2	11.2	18.2	
Total	156.9	156.9	188.7	202.1	

Table 5 continued

Research Activity	Level of SY Effort: Current 1/	No Increase 2/	20% Increase	Recommended	Priority Within Activity
Fiber Quality, Processing, and End Use:					
A. Fiber Quality Improvement	11.7	11.7	13.6	12.1	6
B. Fiber Quality Measurement	6.4	6.4	7.7	6.9	4
C. Harvesting, Ginning, and Fiber Preparation	18.0	18.0	21.6	21.6	1
D. Conversion to Yarns and Fabrics	8.1	8.1	9.7	9.7	2
E. Conversion to Finished Products	4.9	4.9	5.9	5.9	5
F. End Use Properties and Products	23.8	23.8	28.5	28.5	3
Total	72.9	72.9	87.0	84.7	
Seed Quality, Processing, and End Use:					
A. Production of Quality Cottonseed	9.6	9.5	9.5	11.4	1
B. Preservation of Inherent Seed Quality	8.2	8.4	8.4	9.9	2
C. Processing and Utilization of Cottonseed	8.1	8.0	8.0	9.6	3
Total	25.9	25.9	25.9	30.9	

Table 5 continued

Research Activity	Level of SY Effort: Current 1/	No Increase 2/	20% Increase	Recommended	Priority Within Activity
Cotton Marketing and Economic Analysis:					
A. Government Programs and Policies Affecting Cotton	1.4	3.0	3.5	4.0	1
B. Foreign Market Development	0.3	1.5	2.5	3.5	2
C. Cotton Supply, Demand, and Price Analysis	8.1	7.9	8.5	8.5	3
D. Efficiency in Marketing Cotton	4.4	5.0	5.3	6.0	4
E. Production Systems for Cotton	4.8	4.0	5.0	6.0	5
F. Performance of Marketing Systems	5.0	3.0	3.0	3.0	6
G. Competitive Interrelationships in the Cotton Sector	0.4	0.0	0.5	1.0	7
H. Product Development	0.0	0.0	1.0	1.0	8
Total	24.4	24.4	29.3	33.0	

Table 5 continued

Research Activity	Level of SY Effort: Current 1/	No Increase 2/	20% Increase	Recommended	Priority Within Activity
Resource Conservation (Divided into 3 subareas)					
Conservation of Energy:					
A. Production Practices to Reduce Energy Requirements	4.8	2.7	3.3	5.6	3
B. Harvesting Technology to Reduce Inputs and Environmental Problems Created by Cotton Dust	1.2	0.8	1.4	1.7	4
C. Ginning Technology for Energy Conservation	0.6	0.6	0.7	2.0	2
D. Energy Reduction in Processing of Lint and Seed	0.7	0.3	0.4	1.1	1
Total	7.3	4.4	5.8	10.4	
Conservation of Soil and Water:					
A. Cultural, Tillage, and Pest Management Practices for Improved Soil Properties, Crop Production, and Reduced Runoff to Minimize Soil Erosion and Contamination of Waterways.	1.7	1.1	1.2	7.0	1
B. Water and Energy Conservation Through Improved Irrigation Scheduling, Fertilizer Technology, and Growth Regulator Use	0.5	0.5	0.6	11.0	2
C. Develop Cultivars for Improved Efficiency Under Environmental Stress	0.0	0.4	0.4	10.0	3
D. Improved Soil and Water Resource Management for Crop Production Efficiency Through Modeling and System Simulation	0.2	0.2	0.2	2.0	4
Total	2.4	2.2	2.4	30.0	

Table 5 continued

Research Activity	Level of SY Effort Current[1/]	No Increase[2/]	20% Increase	Recommended	Priority Within Activity
Conservation of Chemicals:					
A. Chemical Conservation in the Processing of Cotton Lint and Seed	1.3	1.0	1.0	1.0	6
B. Production Efficiency and New Cultural Systems to Conserve Chemicals	0.4	0.4	0.5	1.5	2
C. Precise Application of Agricultural Pesticides - Conventional Equipment	0.7	0.6	0.6	1.6	4
D. Precise Application of Agricultural Pesticides - New Techniques	2.1	2.1	2.7	3.9	1
E. Fertilizer Conservation	0.3	0.3	0.4	1.1	3
F. Simulation Models to Optimize Pest Control	0.8	0.8	0.8	1.2	5
Total	5.6	5.2	6.0	10.3	
Grand Total (Resource Conservation)	15.3	11.8	14.2	50.7	

Table 5 continued

Research Activity	Level of SY Effort: Current 1/	No Increase 2/	20% Increase	Recommended	Priority Within Activity
Environmental Quality:					
A. Environmental Pollution from Cotton Production	2.6	2.6	3.1	5.7	1
B. Control of Environmental Quality in Cotton Gins and Cottonseed Oil Mills	1.7	1.7	2.1	7.2	3
C. Control of Environmental Quality in and Around Textile Mills	0.9	0.9	1.1	5.0	2
Total	5.2	5.2	6.3	17.9	
Health and Safety:					
A. Elimination of the Causative Agents of Byssinosis and Control of Cotton Dust	11.4	18.5	28.0	28.0	1
B. Identification, Control, and Elimination of Mycotoxins and Environmental Contaminents in Cottonseed Products	8.4	8.4	10.0	10.0	2
C. Improved Flame Retardance and Smolder Resistance for Cotton End Use Products	35.2	28.1	28.1	28.1	3
D. Identification, Control, and Elimination of Pollution from the Wet Processing of Cotton	1.8	1.8	2.1	2.1	4
Total	56.8	56.8	68.2	68.2	
GRAND TOTAL	430.9	425.3	505.7	594.4	

1/ Number of current SY's represents the task force's best estimate for 1979 and thus these data vary from the number shown in Tables 3 and 4, which are based on the 1977 CRIS printouts.

2/ Assumption is no increase in funding. In certain cases (see detailed sections) a decrease in SY's is recommended with a recommended increase in funding per SY.

Table 6. Summary of current and recommended scientist years (SY's) for each research problem area (RPA) concerning cotton within the CRIS classification system

		Level of SY Effort			
RPA	Title	Current 1/	No Increase 2/	20% Increase	Recommended
102	Soil, plant, water, nutrient relations	1.1	1.4	1.7	6.0
103	Salinity management	0.1	0.1	0.1	4.5
105	Conserv. use of water	5.7	4.1	4.9	14.0
106	Drainage and irrigation systems	0.0	0.0	0.0	2.5
107	Watershed protection	0.0	0.0	0.3	1.5
109	Weather adaption and modification	0.0 3/	0.0	0.0	0.0
207	Control of insects	105.5	105.6	126.3	127.4
208	Control of diseases and nematodes	44.6	44.3	53.2	60.8
209	Control of weeds	10.3	10.3	12.4	20.4
214	Protection from pollution	0.0 3/	0.0	0.0	0.0
307	Improved biological efficiency	70.3	69.3	83.5	105.5
308	Mechanization of production	19.1	19.4	22.9	37.3
309	Production management systems	6.5	4.9	6.0	10.4
405	Production for improved acceptability	17.5	16.9	18.5	17.4
406	New and improved food	10.5	10.4	10.4	12.5
407	New and improved feed, textile, and industrial products	46.3	44.4	53.0	54.0
408	Quality maintenance in storage and marketing	0.1	0.2	0.2	0.2
501	Improved grades and standards	6.8	6.8	7.9	7.3
503	Marketing efficiency	5.9	6.5	7.1	7.8
506	Supply, demand, and pricing	8.1	7.9	8.5	8.5
507	Competitive relationships	0.4	0.0	0.5	1.0
508	Domestic market development	0.0	0.0	1.0	1.0
509	Performance of marketing systems	5.0	3.0	3.0	3.0
601	Foreign market development	0.3	1.5	2.5	3.5
702	Protect food and feed from toxins	11.0	11.1	12.7	13.2
705	Selection and care of clothing and household textiles	0.1	0.1	0.1	0.1
708	Human nutrition	0.0 3/	0.0	0.0	0.0
709	Reduce hazards to health and safety	51.3	51.1	61.6	63.1

1/ Number of current SY's represents the task force's best estimate for 1979 and thus these data vary from the number shown in Tables 3 and 4 which are based on the 1977 CRIS printouts.

2/ Assumption is no increase in funding. In certain cases (see detailed sections) a decrease in SY's is recommended with an increase in funding per SY.

3/ CRIS for FY 1977 indicates SY's in this RPA, but subcommittee task force could not identify as active in 1979.

Table 6 continued

RPA	Title	Current 1/	No Increase 2/	20% Increase	Recommended
		Level of SY Effort			
808	Government programs to balance output and demand	1.4	3.0	3.5	4.0
901	Alleviation of pollution	3.0	3.0	3.9	7.5
	Total	430.9	425.3	505.7	594.4

RESEARCH OPPORTUNITIES
BIOLOGICAL EFFICIENCY

(Includes Portion of Research in

Research Problem Area 307)

SITUATION

Increased production efficiency for cotton during the last 30 years is a matter of record. It is also a matter of record that these increases in production efficiencies generally reached a plateau more than a decade ago, and there is some evidence that producers in certain areas have experienced a measureable decline in production efficiency during the last 5 years. Resulting acreage shifts and attending uncertainties of supply have jeopardized the future of cotton as a major U.S. industry.

Major advances in production technology during this 30-year period generally reflect advances by cotton breeders, and by those involved in mechanization and chemical weed control developments. The presence of a general yield plateau or localized decline reflects, in part, a failure to integrate the new cotton production technology within limits of the inherent biological efficiency of the cotton plant. Inherent biological efficiency of the cotton plant in specific situations may have become limited by an ever-narrowing genetic base. There is some evidence that cultivars now being grown are more sensitive to cultural stresses than those grown 30 years ago. The lack of basic information concerning the physiological processes that are common to cotton may have limited the development of external buffers against these seasonal stresses. This, coupled with increased pressures from old and new insect disease pests, has given cotton serious problems of a predictable supply and of escalating production costs. The solution to many of these problems rests with the development of procedures whereby increased biological efficiency in cotton can be realized for all areas of production. A need for improving biological efficiency in cotton was documented in 1973, but implementation of these needs has not materialized.

Yield per unit area of land has been a common measure of production efficiency. This has encouraged cotton breeders, using an arbitrarily selected standard level of production technology, to select for maximum yield when these "standards" are utilized by the growers. Production agronomists and engineers have subjected one arbitrarily selected cultivar to varying inputs and have released subsequent yield enhancing recommendations. In too many instances, the ultimate package of recommendations chosen by the grower has not delivered expected results. To blame unexpected weather patterns for these failures to meet expectations, while temporarily acceptable, is to deny the failure to support research in basic physiology of the cotton plant as a prerequisite to the integration of production technology advances made by breeders, agronomists, engineers, entomologists, pathologists, and weed scientists.

Escalating production costs have tempted growers to use production short cuts. In certain instances, adverse weather and/or unexpected pest problems drastically reduced both yield and quality of fiber. More of this can be anticipated in the future, unless these and other production short cuts are evaluated in each production area.

Cropping systems that include cotton have not been competitive when land-use decisions were made in specific areas of the traditional Cotton Belt. Part of this production loss has been picked up in other areas, some of which have higher climatic risks. The resulting supply uncertainty has an obvious impact on efforts to move cotton into end-use marketing channels. Making cropping systems that include cotton more comcompetitive when land-use decisions are made is a challenge that can only be met by having a reservoir of new technology generated by expanded research having biological improvements as its general objective.

SPECIFIC RESEARCH ACTIVITIES

A. Basic Research on Physiological/Biochemical Processes

1. SY Situation:

Support level	Number of SY's			RPA distribution
	SEA-AR	SAES	Total	
Current	7.2	6.2	13.4	307
No Increase	14.1	7.7	21.8	307
20% Increase	16.9	9.2	26.1	307
Recommended	18.3	10.0	28.3	307

2. Priority: 1

3. Situation: The biological efficiency of the cotton plant can be no greater than the structure generated by its basic physiological processes. The upper limits of this efficiency have not been determined because of obvious gaps in our understanding and knowledge of these processes and pathways. Surely, certain of these processes and pathways could be modified if there was a reservoir of physiological information available to plant breeders, agronomists, engineers, those who are trying to develop the pest management systems needed for cotton's survival and to those who are developing cultural systems entailing lowered production costs. Also, it can be assumed that cotton will continue to be grown in areas subjected to critical environmental stresses. Practical buffers against these temporary stresses can come only from a full understanding of the basic physiological processes affected.

4. Objectives: (In order of priority) (a) Identify those physiological processes (or pathways) that effect biological efficiency in cotton. (b) Develop methods for measuring and manipulating these processes (or pathways) to increase the cotton plant's biological efficiency.

5. Research Approaches: (In order of priority)

   a. Determine the environmental and genetic parameters affecting components of carbon metabolism (photosynthetic CO_2 fixation, dark and light respiration, mobilization and storage of carbohydrates) in cotton.

   b. Develop an understanding of how internal and external factors in cotton roots affect physiological processes and flow patterns within these roots under an array of field conditions.

   c. Determine the biochemical, physiological and morphological factors operative during seed development, maturation, quiescence and germination and their effects on planting seed quality and seedling vigor.

   d. Develop critical, simple tests that can be used by breeders, pest management specialists and agronomists to monitor physiological processes as they seek new technology designed to improve cotton's biological efficiency.

   e. Elucidate the water requirements and drought tolerance/avoidance mechanisms of cotton.

   f. Expand understanding of the hormonal regulatory systems involved in germination, flower initiation, fruit shedding and biomass distribution.

   g. Investigate nitrogen metabolism in cotton.

B. Improved Production Practices for Increasing Yields

1. SY Situation:

Support level	Number of SY's			RPA distribution
	SEA-AR	SAES	Total	
Current	4.2	8.9	13.1	307
No Increase	1.0	18.2	19.2	307
20% Increase	1.2	21.8	23.0	307
Recommended	1.3	23.7	25.0	307

2. Priority: 3

3. Situation: Environmental (climatic) factors affect plant processes that can negate or amplify genotypic potentials. Recurring factors may be bypassed by modifying the cultural system so that the cotton plant approaches the anticipated stress period in a less vulnerable position. Short-season cottons, integrated pest management systems and chemical crop termination represent bypass

components in a production system that has yet to emerge for want of integrated, cooperative research in the several production areas. At the other extreme, where external inputs are either controlled or exert no deleterious effects, integrated and cooperative research is needed involving all cotton research disciplines. If optimum packaging can be given the several components of production technology, much of cotton's instability of supply can be eliminated.

4. Objective: (1) To develop optimum production packages for all areas and systems of production.

5. Research Approaches: (In order of priority)

   a. Determine the interacting effects of cultivar, planting dates, stand geometry, fertility and other cultural variables on production efficiency.

   b. Investigate the effects of environmental stress on growth and development, and develop chemical and cultural treatments to mitigate these effects.

   c. Develop cultural/management principles and techniques that optimize lint and seed yields, and that are energy efficient and environmentally superior.

   d. Develop reliable, practical techniques of crop monitoring that can be utilized in making crop management decisions.

   e. Determine the effects of various cultural factors on development and maintenance of planting seed quality.

C. Development of Superior Germplasm

1. SY Situation:

	Number of SY's			RPA
Support level	SEA-AR	SAES	Total	distribution
Current	12.9	23.6	36.5	307
No Increase	9.2	12.8	22.0	307
20% Increase	11.0	15.4	26.4	307
Recommended	12.0	16.6	28.6	307

2. Priority: 2

3. Situation: Germplasm of the races, obsolete varieties and genetic marker stocks of the two locally cultivated species (*Gossypium hirsutum and G. barbadense*), as well as related wild and cultivated species of the genus, have been collected, catalogued,

classified, maintained and distributed for evaluation and screening. There is a need to continue the collection, evaluation, and maintenance of these materials to reduce genetic vulnerability, and to provide additional genetic traits of economic value to the cotton industry.

New cultivars are being developed and others are needed for special cooperative research ventures simultaneously involving the several professional disciplines doing cotton research. Specially developed primary breeding stocks having one or more special traits now are being made available to public and private breeders and more are needed. All of this involves specific genes in the germplasm bank. The accessibility of these genes varies; some can be retrieved by orthodox genetic manipulations, others--particularly those in exotic species--will require the most sophisticated technology available. Continual genetic improvement of cultivated cotton is imperative to insure that newer cultivars possess fitness, efficiency and quality features needed to improve cotton's competitive strength.

4. Objectives: (In order of priority) (a) Collect, maintain and evaluate germplasm of *Gossypium* and related genera. (b) Develop new cultivars possessing useful potentials that warrant evaluation by interdisciplinary research teams and by public and private breeders. (c) Develop new cultivars having improved production efficiency in specific production areas and demonstrate this advance in appropriate field trials.

5. Research Approaches: (In order of priority)

   a. Collect, evaluate and maintain potentially useful germplasm of *Gossypium* and related genera.

   b. Develop basic genetic and cytogenetic knowledge and materials to facilitate the transfer and utilization of useful genetic traits and gene combinations available in germplasm collections.

   c. Breed for new or modified combinations of yield components, fiber and seed properties, growth and fruiting characteristics, pest resistance, stress tolerance and other traits of economic value for development of superior cultivars adapted to varied environmental and cultural conditions.

   d. Maintain a program of coordinated beltwide performance testing of advanced experimental strains and commercial varieties to evaluate agronomic and quality parameters under varied climatic conditions.

RESEARCH OPPORTUNITIES
ENVIRONMENTAL STRESS

(Includes Portions of Research in Research

Problem Areas 102, 103, 105, and 307)

SITUATION

The cotton plant is cultured in widely diverse climates far removed from its native subtropical semiarid origins. Through selection, breeding, and cultural techniques cotton has been adapted to a wide variety of soil types, temperature and water extremes and insect and disease pests. Extension of cotton production to the limits of its environmental tolerance has created serious production problems and economic losses due to unpredictable weather variability. As a result of climatic impact, quantity and quality of cotton fiber fluctuate, resulting in shifts in price and demand and an unstable market.

The primary environmental factors contributing to crop quantity and quality loss are temperature extremes, water quality and availability, and soil chemical and physical properties.

Private and public breeders have developed varieties with tolerance to climatic extremes. For example, varieties developed for the Texas High Plains have tolerance to cold, drought and wind, while California Acalas are designed for high yield under high production inputs of water and fertility. Cotton tolerates a fairly wide range of soil types and is moderately heat tolerant; production area is perhaps more limited by low temperatures than by heat or soil characteristics. High temperatures can decrease fruit set and boll development but do not cause losses comparable to those caused by low temperatures or droughts Water deficit is the major limiting factor in much of the rain-grown cotton area and water constitutes a major cost in irrigated culture.

Research to reduce climatic stress effects on cotton yield and quality entails three general approaches: (1) Genetic selection for resistance or tolerance to combinations or single adverse factors such as heat, drought, cold, or mineral stress; (2) Cultural practice to alter the environment such as irrigation or fertilization to reduce the level of stress impacting upon the plant; and (3) Alteration of the plant by chemical or physical means to increase stress resistance.

There is ample evidence for existence of a wide genetic base for stress resistance. Variability for adaptation to soil pH and mineral extremes, cold, heat, drought and salinity exists in domestic or wild species. The task, in part, remains for researchers to develop definitive methods to screen for stress resistance; thereby, providing the tools needed by breeders to isolate and develop genetic lines for specific stress conditions.

Much basic physiological knowledge concerning how the cotton plant responds to stress remains to be elucidated. The critical growth and fruiting periods most sensitive to stress are not well established. The extremes of stress that plants can tolerate and continue to be productive are not known. The methods for measurement of stress response can be improved. Such information is needed to provide the basic measuring tools for improvement of plant stress resistance through genetic and cultural methods. (See Subcommittee 10, Research Area A; Subcommittee 70, Research Areas 72B, C, D, and E.)

SPECIFIC RESEARCH ACTIVITIES

A. Plant Water Stress

1. SY Situation:

Support level	Number of SY's			RPA distribution
	SEA-AR	SAES	Total	
Current	4.7	0.9	5.6	105
No Increase	3.6	0.4	4.0	105
20% Increase	4.3	0.5	4.8	105
Recommended	7.0	1.5	8.5	105

2. Priority: 1

3. Situation: Recent droughts in the Mid-South, Southern High Plains, and Western Regions of the Cotton Belt illustrate the devastating effects of water stress and accentuate the necessity of maintaining favorable plant water balance to achieve suitable cotton yields. Plant water stress in cotton occurs to varying degrees each year in dryland production areas, and may occur near the end of irrigation cycles in semiarid and arid climates. The probability of cotton experiencing water stress in the future will increase due to declining water tables, increased pumping costs, and competition between agriculture and other industries for available, high quality water. Greater frequency of moisture stress will increase an already serious problem of yield instability and may force producers to divert productive agricultural land to other crops and to non-agricultural uses. Research in several important areas of crop-climate interactions will provide new varieties and management techniques to either reduce the probability that the crop will experience damaging water stresses or better tolerate those stresses when they do arise.

4. Objective: To develop genetic stocks with inherited traits which enable the cotton plant to avoid or tolerate plant water stress in such a manner as to increase yield and maintain quality of harvestable products, and to evaluate methods to conserve rainfall and to make more efficient use of irrigation water.

5. Research Approaches:

   a. Define the adaptive responses to drought and determine whether these responses enhance avoidance or tolerance to plant water stress and develop techniques suitable for rapid evaluation of these adaptive responses. Priority 1.

   b. Develop new genetic stocks with more highly developed physiological mechanisms which will enhance overall drought resistance. Priority 1.

   c. Determine the relation between water stress and efficient utilization of mineral fertilizers, primarily nitrogen and phosphorus. Priority 1.

   d. Determine the growth stages which can tolerate moderate water deficits without serious yield reductions so as to more efficiently time irrigation water applications. Priority 2.

   e. Evaluate genotype X moisture level interactions to estimate the specific genotype needed under certain levels of moisture stress. Priority 2.

   f. Evaluate supplemental irrigation in traditionally non-irrigated areas to achieve higher efficiency in use of applied water than is achieved in arid regions. Priority 2.

   g. Explore mechanical and chemical means of modifying the plant to enhance its avoidance or tolerance of internal water deficits. Priority 3.

   h. Determine the probability of plant water stress and water use characteristics based upon long-term weather records and soil properties. Priority 3.

   i. Evaluate desirability of stressed plants as hosts for insects and the relation of stress-induced alterations in morphology and physiology on the dynamics of insect populations. Priority 3.

B. Chilling Stress

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	1.7	0.9	2.6	307
No Increase	1.3	0.4	1.7	307
20% Increase	1.6	0.6	2.2	307
Recommended	4.0	2.0	6.0	307

2. Priority: 2

3. Situation: Replanting to replace cold-damaged seedling stands costs the cotton industry as much as $60 million annually and involves as much as 10 percent of the planted acreage. Incidence of chilling temperatures is marked by great increases in seedling disease problems. Losses caused by reduced yield due to skimpy stands and delayed maturity are compounded by lower quality and increased late season insect control costs. Low temperatures during the boll maturing season reduces lint quality and yield, especially in the High Plains and northern Mississippi Valley of Arkansas and Missouri. Research is needed to produce genetic selections more tolerant to chilling, and to develop cultural or chemical methods to ameliorate chilling effects.

4. Objectives: To reduce the damage of low temperatures during germination and seedling development, and during boll maturation through developing cotton genetic lines that tolerate or escape cold; and by chemical or cultural manipulation of the plant or environment.

5. Research Approaches:

   a. Determine the genetic variance in cotton seedling ability to harden against cold in terms of time required and level of hardening. Priority 1.

   b. Interrelate cold stress, root water uptake, and injury. Priority 2.

   c. Interrelate cold stress and seedling disease. Priority 2.

   d. Develop chemical means of ameliorating cold stress. Priority 3.

   e. Define the types of temperature conditions that cause injury. Priority 4.

   f. Define the chemical and physical nature of cold injury. Priority 4.

C. Mineral Stress and Fertilizer Efficiency

1. SY Situation:

	Number of SY's			
Support level	SEA-AR	SAES	Total	RPA distribution
Current	0.5	0.4	0.9	102
No Increase	0.9	0.4	1.3	102
20% Increase	1.1	0.5	1.6	102
Recommended	3.0	2.0	5.0	102

2. Priority: 3

3. Situation: Nutrient stress, defined in terms of plant responses to shortages or toxic amounts of particular mineral nutrient elements in the soil, has been studied for many years in classic soil fertility experiments. Reports of the results, expressed as recommendations for kinds and amounts of fertilizer required by particular crop and soil combinations, have generally ignored the large variability within crop species which might permit adaptation of plants to existing soil conditions.

   As emphasis is placed on control of nonpoint-source pollution of streams and groundwater while the cost of soluble fertilizers (e.g., N and K) increases, fertilizer use efficiency must increase. The patterns of root growth and uptake activity found under all kinds of soil and climatic variability are poorly understood. Management has tended to stress labor efficiency rather than resource allocation efficiency.

4. Objectives: The objectives are to (a) minimize yield reductions that result from nutrient deficiencies, excesses, or imbalances, and (b) to minimize inorganic nutrient content of ground water and runoff. Soluble nutrients should be utilized by the crop rather than contributing to water pollution.

5. Research Approaches:

   a. Investigate management strategies for minimum loss and maximum uptake of soluble nutrients. Priority 1.

   b. Search for genetic variability in plant responses to mineral stresses and in ability to absorb nutrients from the soil. Priority 2.

   c. When lines showing differences become available, compare morphological and metabolic characteristics to elucidate the mechanisms of adaptation to deficiencies, excesses, and imbalances. Priority 3.

D. High Temperature Stress

1. SY Situation:

	Number of SY's			RPA
Support level	SEA-AR	SAES	Total	distribution
Current	0.7	0.6	1.3	307
No Increase	0.9	0.4	1.3	307
20% Increase	1.1	0.8	1.9	307
Recommended	1.5	1.0	2.5	307

2. Priority: 4

3. Situation: High temperatures occur at least periodically in most cotton-growing areas and occur almost continuously from June through August in irrigated areas at low elevations in the desert Southwest. In dry areas, extreme day temperatures may cause some enzyme denaturation and partial loss of membrane integrity. In humid areas or during humid periods, hot nights probably cause carbohydrate depletion through high rates of dark respiration. Hot weather increases boll shedding and may affect square shedding, but possible effects on square shedding require further research.

   Cultivars differ in heat tolerance, in some cases because of differences in pollen sterility at high temperatures. Other factors may also be involved and should be investigated.

   High temperatures and water status are interrelated. Periods of drought are usually hot. High temperatures increase transpiration rates and desiccation. And, water availability affects leaf and canopy temperatures through its effect on transpiration rate.

4. Objective: Decrease the adverse effects of high temperatures on fruiting, fruit abscission, and yield.

5. Research Approaches:

   a. Identify and select heat-tolerant genetic materials. Priority 1. (Suitable for commercial effort.)

   b. Determine the effects of temperature on dark respiration, photorespiration, and photosynthesis in cultivars that differ in heat tolerance. Priority 2.

   c. Investigate the relative effects of day temperature versus night temperature on pollen sterility, and determine the relative importance of pollen sterility as a component of heat sensitivity in cultivars that differ in heat tolerance. Priority 2.

   d. Investigate the effects of high temperatures on square shedding. Priority 2.

   e. Investigate possible effects of inorganic nutrient status on heat tolerance. Priority 2.

   f. Investigate the effects of high temperatures on protein denturation and enzyme inactivation in plants that differ in heat tolerance, either because of adaptation or genetic differences. Priority 3.

   g. Determine possible differences in membrane lipid composition in leaves of plants that differ in heat tolerance. Priority 3.

E. Increase Production on Salt-Affected Soils

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	0.0	0.1	0.1	103
No Increase	0.0	0.1	0.1	103
20% Increase	0.0	0.1	0.1	103
Recommended	2.0	1.0	3.0	103

2. Priority: 5

3. Situation: Salinity adversely affects cotton production, especially in arid and semiarid regions where irrigation is practiced. The deteriorating quality of water in many river systems and the prospect of diminished water supplies are of major concern for maintaining production in the future.

   An extensive collection of *Gossypium* germplasm should be screened for tolerance to salinity. Physiological and biochemical mechanisms of salt tolerance must be identified to provide the geneticist with specific selection criteria. Rapid screening techniques to evaluate these criteria are needed to select genotypes with heritable salt-tolerant traits.

4. Objectives: Develop genotypes with acceptable seed and lint yields and quality and improved salt tolerance.

5. Research Approaches:

   a. Collect and evaluate the salt tolerance of potentially useful germplasm of *Gossypium*. Priority 1.

   b. Determine the heritability of salt tolerance characteristics, the number of genes involved, and their dominance patterns. Priority 2.

   c. Determine mechanism of salt injury and the morphological, physiological, and biochemical bases of salt tolerance. Priority 2.

RESEARCH OPPORTUNITIES
PEST CONTROL

(Includes Portions of Research in Research

Problem Areas 207, 208, and 209)

SITUATION

Losses to pests and cost of pest control are major limiting factors in economical production of cotton. Recent Beltwide surveys indicate that the annual costs for controlling weeds and insects were $130 million and $192 million, respectively. Annual cotton losses due to weeds and insects exceeds 11 percent of the value of U.S. cotton production. Losses due to diseases and nematodes probably exceed 10 percent of the annual crop value. Combined pesticide usage for control of diseases, insects, nematodes, and weeds, assuming multiple applications will equal more than 80 million accumulated acres of cotton each year. Control of pests is an essential requirement for efficient cotton production. United States cotton farmers must be prepared to control at least 8 insects (aphids, thrips, fleahoppers, lygus, spider mites, boll weevil, bollworm, budworm and pink bollworm), 7 diseases (seedling disease, bacterial blight, the *Fusarium* wilt root-knot nematode complex, *Verticillium* wilt, boll rot, *Phymatotrichum* root rot, and fungal leaf spots) and nematodes. All farmers must contend with yield losses caused by at least one-half of these pests. Many must be concerned with as many as 14. In addition, all growers must control a complex of weed pests.

Farmers have used a wide array of cotton pest control techniques, procedures, and devices. Competition by weeds is minimized mechanically, by crop rotation, with herbicides, and with judicious procedures that improve the growth capabilities of cotton. Diseases and nematodes are controlled in many situations by utilizing disease resistant varieties, crop rotations, dates of planting, chemicals, and harvest dates. There is strong dependance for control of insect and mite pests by naturally occurring biological controls. Farmers have used many techniques to control pests, but cotton production still depends heavily on pesticides.

Cotton diseases are dynamic and vary with changes in fertility, cotton varieties, cultural practices, weather conditions, soil moisture, and with the use of other pest control measures. Losses due to cotton diseases continue to increase and the use of fungicides will continue to be necessary for farmers to obtain adequate stands of vigorous cotton seedlings that are essential for maximum yields. We expect continued progress in cotton varietal resistance to specific diseases, but the development of additional fungicides and the implementation of their use in helping make production systems efficient will be necessary. Little is known about economic threshold levels of specific plant pathogens as

related to losses from disease. This is a complex matter, since disease incidence is altered by a number of environmental conditions, different agronomic practices including cultivars and the use of other pesticides. Because many uncontrollable factors affect the severity of different diseases, it is necessary to identify these limitations through cooperative cotton production research and find the means to overcome them in order to devise a total control program.

Cotton insect problems are dynamic and may be different each growing season. They are subject to change in severity with shifts in weather conditions, cotton varieties, fertility levels, time of planting, and other agronomic practices. The threshold level at which economically important yield losses are caused by specific populations of individual insects varies with changes in cotton varieties, fertility levels, other agronomic practices and market prices. Threshold levels of the economically important insects have not been established under these varying conditions. Economic threshold information is critically needed by producers and extension personnel, particularly as related to successful use of the newer and more expensive insecticides. The scope of the problem of developing economic thresholds of specific insects demonstrates the critical need for interdisciplinary cooperation among scientists. Establishment of these threshold levels will require close cooperation of entomologists, plant pathologists, agricultural economists, agronomists, and other disciplines.

Increased cotton losses due to nematodes have been recognized in a number of States in recent years. In many localities losses to nematodes in individual fields may exceed losses due to other pests. Progress is expected in the development of plant resistance to specific nematodes in cotton varieties. Meanwhile, use of nematicides will continue to be the primary means of controlling specific nematodes. Efficacious and more cost-effective nematicides are needed. Much of the research to develop these should be interdisciplinary among the crop protection disciplines to avoid antagonism and other adverse interactions. Also, little is known about economic threshold levels of specific nematodes, especially as related to environmental conditions, different agronomic practices, and the use of other pesticide programs. This research must be closely coordinated with that of other disciplines to achieve maximum results.

The importance of weed control in cotton has increased partially because ecological shifts have resulted in the presence of weed species that are even more difficult to control than those that were most troublesome in the past. Prickly sida and cocklebur, for example, were virtually unknown as weeds in cotton a decade ago, but are now listed among the top 5 weeds causing greatest yield losses in cotton. Johnsongrass poses a major threat to the cotton producer and is the worst weed in cotton--it causes 16.5 percent of all cotton losses due to weeds. Other perennial weeds that are increasing in severity include burmudagrass, horsenettle, field bindweed, and other perennial vines. Successful control of these will continue to be possible only through judicious use of herbicides. These and other resistant weeds and herbicide-tolerant crop varieties should be the primary target for new research.

Disease, insect, nematode and weed pests have traditionally been considered independently with respect to management/control practices. Scientists who deal with the pest management aspects of cotton production have come to recognize a number of interactions between the various elements used for their regulation or control. Perhaps the most striking are suppression of beneficial insects by insecticides, changes in the weed complex in fields that are treated with selective herbicides and loss of cotton stands to seedling diseases when an insecticide is used at planting time without the addition of a suitable fungicide. Also recognized and perhaps less well understood are apparent changes in fruiting pattern of the cotton plant in response to some insecticide uses, differential response of cotton cultivars to some insecticides, herbicides and fungicides, and interactions of these various pesticides when used in combinations or in subsequent applications during the course of the season.

Insecticides applied to cotton for control of injurious insects have caused severe losses to honey bees, *Apis mellifera* L. Losses of other bee and fly pollinators undoubtedly occur. While such pollinating insects are not usually considered essential for cotton production, they are of absolute importance for several other crops that are frequently grown in close association with cotton. Insect pollination may gain significance to the cotton industry if hybrid production becomes practical. Furthermore, the honey production industry is strongly dependent on cotton nectar in areas of this crop's production. Research is needed that will clarify the impact of pesticides on both *Apis* and non-*Apis* pollinators and will lead to reductions in pollinator losses. The relationships of various pest management practices to pollinator efficiency must also be established. Pesticides and pesticide use programs must be developed that adequately protect these beneficial insects.

Several cultural practices are used to suppress or control various insect and disease pests. At the same time, there usually has been little attention given to their effect on beneficial arthropods, nematodes, and/or the soil microflora. Effective utilization of biological control, especially for diseases and nematodes, demands better understanding of interactions by these and the chemical elements of management.

Seedling diseases appear to be variable in severity with seemingly minor changes in agronomic practices and are recognized to respond to the use of both insecticides and fungicides at planting time. There are also reports of seedling disease response to herbicide use. At the same time, little attention has been given to developing a functional understanding of the reasons for these differences in response. The use of pesticidal compounds may be altering the susceptibility of the plant to pathogens or may be influencing naturally occurring biological control agents.

Interactions of pests and of their respective control strategies make integration of management considerations essential. While some areas of interaction are documented, there are many more that are "suspected" or "observed" but remain to be proven. Even where interactions are confirmed, the underlying mechanisms of interaction are not known. Scientists of several disciplines must work to eliminate the undesirable plant-pest-pesticide interaction.

While the concept of cooperative research between disciplines is old, we feel that increased emphasis should be placed on the importance of cooperative research to achieve maximum benefits for the cotton producer. For example, our objective on the development of more efficient and effective delivery systems will require cooperative research between agricultural engineers, agronomists, entomologists, weed scientists, plant physiologists, plant pathologists, nematologists, and agricultural economists. The development of needed information on pesticide interactions and pest threshold levels as related to timing the application of pesticides for maximum effect is one example of the need to involve essentially all disciplines in cotton production research.

Maximum utility of the spectrum of agricultural practices that impinge on pests requires an understanding of their interaction. This may best be accomplished through a systems approach which can utilize plant and insect models to aid us in better recognizing and understanding the interactions. This requires people with training that will enable them to put the elements in perspective and to interact with scientists of greater specialization.

Long-range pesticide interactions or pesticide-agronomic practice interactions are seldom recognized. This requires a type of record keeping that is not presently widely utilized by growers or the agricultural service industry. Computer programs must be developed that are understood and readily utilized for record keeping. This will enable storage and recall of pesticide and farm practice information for utilization in studies of interactions. This is a type of service that may best be developed by cooperative extension and/or the agricultural service industry.

The private sector of industry contains many individuals with strong expertise and in some cases has facilities that equal or exceed those of the public agencies. These units can fit into pest management research since they already occupy much of the pesticide discovery and development role. In association with developmental research the private sector must conduct a great deal of toxicology and physiology research. They should be encouraged to take a greater role in pesticide interaction, and pesticide-plant interaction research and development of pest resistant crop varieties. Not all interactions should be looked upon as deleterious to production or to sales. Some could be used to enhance cotton production potential where properly timed.

SPECIFIC RESEARCH ACTIVITIES

A. Biological Control of Insects, Diseases, Nematodes and Weeds

Note: In addition to traditional biological control this section of the report includes cultural practices, plant growth regulators, microbial agents, behavior modifiers, and genetic methods of control.

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	51.0	20.1	71.1	207
	4.5	6.9	11.4	208
	2.2	1.3	3.5	209
No Increase	51.0	20.1	71.1	207
	4.5	6.9	11.4	208
	2.2	1.3	3.5	209
20% Increase	61.2	24.1	85.3	207
	5.5	8.4	13.9	208
	2.7	1.6	4.3	209
Recommended	56.0	22.1	78.1	207
	5.5	8.9	14.4	208
	3.2	2.3	5.5	209

2. Priority: 2

3. Situation: The rising costs of pesticides, increasing pesticide resistance, incidence of hard-to-control weeds, spread of more virulent strains of cotton pathogens, and environmental and energy considerations indicate that emphasis must be placed on development of biological pest control methods utilizing cultural practices, parasites, predators, pathogens, behavioral chemicals such as pheromones, genetic techniques, and physical methods. Principal injurious insects are the boll weevil, bollworm, tobacco budworm, pink bollworm, cotton fleahopper, and lygus bugs. A number of other insects and spider mites also occasionally cause serious damage. Combined yield losses to diseases, including *Fusarium* and *Verticillium* wilts, root-rot pathogens, seedling diseases, nematodes, and boll rots are estimated to be more than 10 percent of the potential crop. Weed competition and contamination of the harvested crop by weed pests also add a significant toll to the losses or production costs.

   Too little is known regarding normal soil microorganisms and their relationship to pest problems and production. We are ill prepared to meet and control bacterial and fungal problems until this fundamental information is available. Also cotton disease control is essential to successful crop management for efficient use of water and nutrients, for biological pest control that depends on earliness and certain other plant characteristics, as well as for reducing the problems of mycotoxins, byssinosis and pollution now confronting the cotton industry.

   Losses to nematodes have increased greatly in recent years. Chemical controls are effective but expensive with some currently in hazard of removal from use which points up the urgent need for research on nematode control. Biological controls are known but have not received adequate study for utilization.

   Weed control still is one of the more significant factors in cotton production costs. Weed competition can result in yield losses in excess of 50 percent with added losses through harvest difficulty and trash contamination. With increasing herbicide use, or predominant use of a single herbicide, the uncontrolled spectrum of weeds has changed in many localities from easily controlled annuals to problem weeds such as Texas panicum, johnsongrass, nutsedge, nightshade, cocklebur, sicklepod, prickly sida, and Florida beggarweed. These weeds have gained major pest status in part through reduced competition brought on by effective control of other pests and elimination of hand hoeing. A review of previous research, including the effectiveness of vigorous, precise and timely cultivation, indicates that we have the diverse tools needed for effectively controlling most of the weeds in cotton. However, research is needed that integrates these diverse tools into effective programs of weed control. Integrated studies on systems of weed control can provide relatively rapid answers to many of the more vexing weed problems facing cotton farmers. The probability for productive experimentation

is very high since previous research has already firmly established the value of the components to be employed in the integrated systems. Limited efforts have been made to identify biological control agents of field bindweed and nutsedge. Biological control agents could undoubtedly reduce the competitive ability of a number of weed pests.

Previous research clearly indicates the value of biological controls in suppression of pest populations. Research also indicates great potential for further utilization of these techniques for control of diseases, insects, nematodes and weeds in production of cotton. Efficacy of these control agents can be greatly enhanced through management programs that use integrated approaches.

Cultural Practices:--A number of cultural practices to reduce cotton pest problems are known. These are early stalk destruction, deep cultivation, crop rotation, and trap crops, as well as crop residue, fertilizer, and irrigation management in affecting plant diseases. However useful, they often do not fit into practical farm management systems. Refinement of the known methods plus more emphasis on large-area multiple crop and pest management systems should lead to expanded uses of many of these cultural and management practices.

Plant Growth Regulators:--The development of chemicals that can be used to terminate growth of cotton plants provides considerable potential for reducing overwintering insect populations. Of particular interest are those chemicals that will terminate vegetative growth and production of new fruit and still allow maturation of bolls. Chemicals now under experimentation show particular promise for plant modifications that will reduce pink bollworm and boll weevil populations.

Plant growth regulators that cause shortened internodes and compact growth habit have appreciably reduced losses to *Verticillium* wilt and boll rots, but are undeveloped for commercial use. The effect of plant growth regulators on other diseases and weeds remains unexplored.

Parasites and Predators:--Naturally occurring parasites and predators can be more effectively utilized through the development of practical sampling procedures and the refinement of predator-prey ratios for use in predicting economic infestations of the bollworm and tobacco budworm. Foreign exploration for beneficial species not known to occur in the U.S. that may effectively attack cotton pests has been limited in recent years and needs to be re-examined (reemphasized). This is particularly true for beneficial species attacking nematodes and weeds where only very limited work has been carried out. Significant advances in augmentation of parasites and predators for control of the bollworm and tobacco budworm, and certain weed species have been made. However, major efforts to reduce costs and design compatible control systems are needed.

Microbial Agents:--Antagonists of diseases and rizosphere enhancement as biological controls of diseases should be studied. Diseases may also be located that can selectively serve to reduce the competitive ability of weeds. Two agents have been developed and registered by EPA for use in the control of the bollworm and tobacco budworm: a nuclear polyhedrosis virus and the HD-1 strain of *B. thuringiensis*. However, neither by themselves are sufficiently effective or economical against *Heliothis* to be a major importance in control of this pest. Two areas of research offer considerable hope for improving this picture. First, further improvements in formulations and application methods should improve the effectiveness of both microbial products. Second, it has been demonstrated that strains of *B. thuringiensis* exist that are more pathogenic to *Heliothis spp.* than the HD-1 strain. Further research in strains and fermentation development could increase the effectiveness and reduce the cost of this agent. Microbial hyperparasites and antagonists have recently given good control of *Verticillium, Rhizoctonia* and *Phymatotrichum* in greenhouse experiments. *Colletotrichum sp.* and nematodes have experimentally controlled several weeds in small cotton fields. Further experimentation is needed to ascertain methodology for use and efficacy of these agents in biological control programs.

Behavior Modifiers:--Pheromones and other important behavior chemicals have been identified for the boll weevil, pink bollworm, tobacco budworm and the bollworm. Methods for utilizing these pheromones for both survey and control purposes are urgently needed.

Fungal pathogens synthesize melanins which are essential for their survival. The chemical tricyclazol inhibits melanin synthesis in *Verticillium and Thielaviopsis* at nontoxic concentrations. This chemical has shown excellent promise for control of rice diseases. This and other melanin inhibitors should be studied for efficacy in pest management programs.

Genetic Methods:--Methods of inducing sterility are available for the boll weevil, pink bollworm, bollworm, and tobacco budworm. Existing mass-rearing techniques and sterilization need to be improved to economically provide more competitive insects. Promising leads have also been identified for potential controls utilizing hybrid sterility and nondiapausing strains.

Methods for producing various mutant strains of *Verticillium and Rhizoctonia* have been refined. Both *V. dahliae and R. solani* are composed of at least 4 geneticly isolated populations with all highly virulent forms on cotton belonging to a single population. Inoculation of cotton with attenuated mutants or mildly virulent populations has controlled *Verticillium* wilt and given substantial yield increases in both the laboratory and field. Practical methods for inoculating large fields have not been developed.

Physical Methods Including Traps:--A number of physical methods including mechanical destruction have shown some promise for cotton pest control. The use of light traps as a survey tool has been developed to the point of testing in extension programs. Further refinement of the use of light traps and pheromone traps for use in survey and detection will continue to improve decision making.

4. Objective: Develop new and improved biological cultural and physical methods that can be used alone or in an integrated program to reduce cotton losses to pests.

5. Research Approaches:

   a. Develop cultural practices such as rotation, planting time, tillage, plant spacing, trap crops, plant growth regulators, and crop sanitation that minimize pest populations. Priority 1.

   b. Study the biology and ecology of key pest species nationally, and internationally, as they interact in the cotton ecosystem, on alternate native hosts, on cultivated crops and on each other. Priority 2.

   c. Locate, evaluate, propagate, and disseminate native and/or exotic biological control agents including pathogens for disease, insect, nematode, and weed control to augment present agents. Priority 4.

   d. Identify and develop behavioral chemicals that may be utilized to detect pests, affect spatial distribution, interrupt mating, and/or destroy various pests. Priority 3.

   e. Develop genetic methods of pest control involving natural mutants, sterility induced by irradiation, chemosterilants, or genetic manipulations resulting in hybrid sterility, conditional lethals, or altered virulence. Priority 5.

   f. Develop physical methods including traps and machines to detect or control pests, predict the buildup of infestations, predict timing of control applications, and to monitor the effectiveness of control measure. Priority 6.

B. Chemical Control of Insects, Diseases, Nematodes and Weeds

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA Distribution
Current	6.1	8.3	14.4	207
	3.2	5.4	8.6	208
	2.0	3.7	5.7	209
No Increase	6.1	8.3	14.4	207
	3.2	5.4	8.6	208
	2.0	3.7	5.7	209
20% Increase	7.3	10.0	17.3	207
	3.8	6.5	10.3	208
	2.4	4.4	6.8	209
Recommended	8.3	11.2	19.5	207
	4.8	6.4	11.2	208
	4.0	8.2	12.2	209

2. Priority: 3. (Note: All subunit entries are on a priority 1-n basis.)

3. Situation: Cotton pest control is presently very dependent on a wide array of chemicals. This situation is likely to continue into the near future and is attendant with a diversity of researchable questions. The plant and its pest complex are highly interactive with production practices and these in turn with pesticide usage. Pest population levels at which pesticide usage can be justified are ill defined. Effective pesticides are sometimes unavailable or the pests have developed resistance and pesticide application technology may inadequately meet the needs of effective distribution and of drift control. While pesticide interactions are recognized at the research level, too little is known about their interactions with respect to productivity by the cotton plant or severity of the several pest types. Growth regulating compounds that are being evaluated as management tools for the pink bollworm or bollworm and for *Verticillium* wilt may also be of value through interaction with pesticides in management programs. We need to address these and other questions in detail.

   The cotton plant-pest complex is highly interactive with production practices. Populations of individual pests may, for example, reach threshold levels that require pesticide treatment, even though the producer has followed acceptable agronomic practices, e.g., bollworm populations may be higher in cotton following soybean production than following other crops, while continuous cotton leads to buildup of soil-borne fungal pathogens. The reasons that acceptable agronomic practices intensify the severity of pest problems is often unexplained from a pest

management standpoint. Moreover, these phenomena can upset a seasonal management system e.g., requiring early insecticide applications for some insects result in insecticide applications before the most advantageous time for different insects. Likewise, the use of herbicides may enhance the need for fungicide seed treatments. These crop-pest interactions are poorly understood and additional research would allow a better understanding as to how pest species react to a wide variety of commonly used production regimes throughout the Cotton Belt.

Little is known about the effect of independent variables, such as planting dates, pesticide rates, moisture, temperature, cotton varieties, fertilizers, fungicides, nematicides, herbicides, and other agronomic practices on either antagonists or synergistic interactions that may occur from multiple use of pesticides. An example of a detrimental interaction is that of systemic insecticides + preemergence applied herbicides on the survival of cotton seedlings. The possibility that other interactions of this type exist should be investigated, but presently there is no ongoing research in this area.

Another area needing research is the determination of the effect of the different combinations of pesticides used in cotton production on the susceptibility of cotton to injury from the drift of nontargeted pesticides. As cotton acreage decreases in certain sections of the Cotton Belt, the likelihood increases that pesticides intended for use in other replacement crops will drift onto cotton plants.

Phytotoxicity to cotton by nontargeted insecticides and herbicides has been shown to be dependent on the herbicides previously applied for weed control and on the susceptibility of the cotton variety. It is possible that other interactions of this type exist and further research could clarify this problem.

There is a basic assumption that pests of cotton cause economic losses only when populations are above a given level of infestation. Such levels of infestation, commonly referred to as economic thresholds, are not necessarily static and are very often dynamic. The threshold of a given pest may be influenced by factors such as time of occurrence, intensity, native populations, maturity status, and physiological condition of the cotton plant, environmental and soil factors, cotton variety, and other agronomic factors. Threshold levels have not been established for most of the common pests that reduce cotton yields and quality, and are needed to enable judicious implementation of pest control measures. The increasing cost of pest control makes the availability of this information necessary to establish what level of infestation of major pests (such as tobacco budworm, plant bugs, root-knot nematodes, fungi, johnsongrass, spurred anoda) should be present to justify the cost of a pesticide and its application.

The continuing availability of effective pesticides is necessary for successful production of cotton in the United States. The use of insecticides selectively in conjunction with biological

and cultural control methods will be molded into integrated pest control programs (IPM) for insect control. Because of the diverse nature of other pests, it is not possible at present to integrate completely the control of weeds, diseases, or nematodes into the insect management programs. Cotton producers depend on the availability of safe cost-effective pesticides for controlling most pests. Thus, continuous cooperation is needed among USDA, University, and State Agricultural Experiment Stations (SAES) and Industry personnel in developing new products as quickly as possible for the control of these pests. Efforts should be made to more effectively coordinate research efforts between all cooperating agencies to be mutually supporting and to avoid unnecessary duplication.

Most pesticides are applied with technology that was developed more than two decades ago. There is still little research conducted toward the development of new application equipment for controlled pesticide placement and to control drift. Additional research is needed to maximize efficacy and to minimize exposure of nontargeted organisms to pesticides. New application technology is needed that would encompass the most efficient methods of applying control agents on the target area by reducing drift onto nontarget areas. Such research should include formulation technology so as to improve application control efficiency while reducing drift onto nontarget areas. Innovative inoculation equipment is needed to field test the potential for cross-protection, using avirulent strains of cotton pathogens to protect against virulent strains for disease control. Agricultural engineers and those in related areas of engineering science are essential collaborators.

Many different pesticides are used in cotton production to control a wide range of insects, diseases organisms, nematodes, and weeds, but little is known about whether or not pesticides have an effect on cotton growth and yield. Studies need to be initiated to determine if there are effects of residues when pesticides are applied in sequence 10 to 20 times per year.

The fate of residues of many individual pesticides has been determined, but there has been essentially no physiological research to determine if there may be an effect from the possible interaction of residues of the many different pesticides used in cotton production.

There are many natural pesticides isolated from plants and microorganisms that are known to affect the growth and development of insects, plants, and animals. Many of these natural compounds could be effective as pesticides and research is needed to establish biological activity for their potential in pest control. Research is needed to: (a) delineate the effect of pesticides on the production of natural pesticidal compounds; (b) determine the effect of natural pesticidal compounds, when identified, on both harmful and beneficial pests; and (c) determine the effect of natural pesticidal compounds on the growth and production of cotton.

Several new growth regulating chemicals will be available for producer use within the next few years. One group of growth regulators will be intended to control vegetative growth and boll set. Research is needed to establish the efficiency of these products in cotton production including their effect in relation to other pesticides used in cotton production. The use of these growth regulators, as they may alter the phenology and morphology of the cotton plant, may also alter existing ecological relationships between pests and cotton. Many interactions are possible between the physiological changes induced by growth regulators and other variables such as the time of applying certain pesticides, choice of varieties, and cultural practices. The introduction of growth regulators into the complex cotton production system could either complicate existing pest control situations and establish new problems, or offer some solution by mismatching stages of crop growth and pest incidence in favor of the plant.

4. Objective 1: Identify interactions of targeted and nontargeted pesticides with cotton varieties, applied nutrients, cultural practices, and edaphic factors in the cotton agroecosystem.

5. Research Approaches:

   a. Determine the effect of time and rate of application of fertilizers and pesticides on the physiology and development of major cotton pests.

   b. Identify the potential hazard from a pesticide-use pattern among the crops grown in typical cotton rotational programs.

   c. Identify predisposal response in agriculturally acceptable rotational crops to the herbicides and insecticides used in cotton.

   d. Determine the effect of cotton pesticides on soil organisms as they may predispose cotton plants to infection by diseases.

   e. Determine genetic variabilities and tolerance to pesticides among cotton genotypes and investigate the feasibility of improving pest control by breeding cotton varieties to increase pesticides tolerance.

   f. Determine the susceptibility of different cotton cultivars to injury and yield loss that may occur from incidental drift of pesticides used in other crops and the interaction of such pesticides with pesticide programs practiced in cotton production.

4. Objective 2: Develop dynamic treatment threshold levels for cotton pests that are compatible with optimum pest management systems and justify each particular control procedure or procedure combination.

5. Research Approaches:

   a. Determine the effect of incident levels of cotton pests on the yield and quality of cotton.

   b. Determine the correlation between environmental conditions that affect threshold levels of cotton pests and optimum growth and most economical yields in cotton.

   c. Determine the response of different cotton varieties to specified periods of minimum pest abundance (pest-free maintenance); determine the period of maximum pest control required to avoid yield losses from competition with specific pests.

   d. Determine and develop more effective procedures for establishing thresholds of weeds, insects, fungi, nematodes and other pests in cotton.

   e. Survey the Cotton Belt for precise documentation of cotton pests; determine the potential for new strains of existing species developing from prolonged use of existing cultural and pest control practices.

4. Objective 3: Develop environmentally-compatible, cost effective pesticides that can be integrated with biological and other control methods for most efficient cotton production.

5. Research Approaches:

   Effective pesticides are urgently needed for improved control or suppression of: (a) bollworm complex (Priority 1); (b) johnsongrass (Priority 2); bollweevil (Priority 3); (d) bermudagrass (Priority 4); (e) nutsedge (Priority 5); (f) pink bollworm (Priority 6); (g) plant bugs (Priority 7); (h) nematodes (root-knot, reniform, and other nematodes) (Priority 8); (i) plant diseases (boll rot, leaf spots, *Phymatotrichum* root rot, *Verticillium* wilt, seedling diseases) (Priority 9); and (j) other perennial weeds (Priority 10).

4. Objective 4: Develop more efficient pesticide delivery systems that maximize efficacy while minimizing exposure of nontarget organisms.

5. Research Approaches:

   a. Develop pesticide application equipment and techniques for dispensing sprays, granules, dust, foams, and other pesticide formulations for more effective pest control.

   b. Develop pesticide application equipment and techniques which reduce or eliminate drift or movement onto nontarget areas.

c. Develop methods and systems for efficient application of pheromones, attractants, repellants, confusants, morphactants, parasites, and predators.

d. Develop equipment and methods to monitor the interaction, biological activity, and weather conditions that affect the susceptibility of target and nontarget species to pesticides in relation to method and/or time of application.

e. Develop application equipment and technology for application of biological control agents.

4. Objective 5: Determine the physiological effects of pesticides, their residues, and degradation products, alone and in combinations, on the growth and yield of cotton, on rotation crops and on selected organisms in cotton ecosystems.

5. Research Approaches:

a. Determine if there is an effect of residues of individual pesticides and combinations of pesticide residues on cotton germination, emergence, diseases, growth, and yield.

b. Determine if there is an effect of residues of various pesticides alone and in combination on cotton growth and yield in interaction with agronomic practices and environmental conditions.

c. Determine if there is an effect of residues of pesticides on the efficiency and efficacy of use of established pesticide treatments, i.e., residues of herbicides, insecticides, nematicides, and fungicides that alter the susceptibility of cotton seedlings; cotton injury that occurs from preemergence-applied herbicides or from synergistic injury of preemergence-applied herbicides plus systemic insecticides and/or fungicides.

d. Determine if there is an effect of residues of pesticides on beneficial organisms in cotton production.

4. Objective 6: Determine the potential for use of natural pesticides isolated from plants and microorganisms as effective biological control agents in cotton production.

5. Research Approaches:

a. Discover, identify, and evaluate secondary compounds that have pesticide activity against weeds, diseases, insects, and nematodes, and/or that affect the degree of control of these pests with pesticides.

b. Isolate, purify, and identify those secondary compounds that either inhibit or stimulate the growth and development of

pests. Especially important are those affecting germination of seed, spores, and hatching of insect eggs.

c. Determine (1) the effect of environment on the persistence, activity, and effectiveness of secondary compounds, and (2) the effect of secondary compounds on the persistence of pesticides and residues.

d. Determine the effect of natural pesticides isolated from plants and microorganisms on cotton production systems.

4. Objective 7: Determine the value of plant modification with chemical growth regulators or by breeding in more efficient pesticide usage.

5. Research Approaches:

a. Determine the influence of altering stages of plant development with growth regulators on pest growth and population levels in relation to quality and yield.

b. Determine if the use of growth regulators has an effect on the efficacy and efficiency of pest control with pesticides, or will induce plant resistance to pests.

c. Elucidate the influence of predisposition of cotton pests to plant hormone substances and determine the effect of hormone substances on the level of control obtained with individual pesticides.

d. Determine the effect of interactions between hormone application, utilization of soil nutrients (fertility), and effective utilization of pesticides.

e. Establish the frequency of occurrence of interactions between pesticides and growth regulators on pesticidal activity.

f. Determine interactions between water utilization and use of hormones on effective pest control.

g. Determine the value of plant characters such as frego bract, okra leaf and dwarf on efficiency of pesticide distribution and resultant pest control.

C. Plant Resistance to Diseases, Insects and Nematodes

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	10.4	8.5	18.9	207
	10.6	12.7	23.3	208
	0.0	0.0	0.0	209
No Increase	10.4	8.5	18.9	207
	10.6	12.7	23.3	208
	0.0	0.0	0.0	209
20% Increase	12.5	10.2	22.7	207
	12.8	15.2	28.0	208
	0.0	0.1	0.1	209
Recommended	14.5	13.2	27.7	207
	14.8	18.2	33.0	208
	0.0	0.5	0.5	209

2. Priority: 1

3. Situation: Cotton farmers must regularly contend with yield losses by at least eight major pest species. Many must be concerned with as many as 14. The most practical approach to combating these diseases, insects and nematodes is through host plant resistance. Chemical pesticides can no longer be counted on alone for three reasons: (1) the cost; (2) restriction on use by EPA; and (3) pest resistance to insecticide. Presently farmers do not have much choice among varieties which have resistance to many of the most important pests. More progress has been made in breeding for disease resistance than insect resistance. Presently a few early maturing varieties and some with the nectariless and open-canopy (okra and super okraleaf) characters may be used for reducing losses caused by insects. Several varieties contain resistance to the wilts and to bacterial blight; however, many current varieties are susceptible to all insects and diseases. Consequently, in order for farmers to more effectively use host plant resistance in controlling losses caused by pests, varieties possessing resistance to more insects and diseases must be developed. Furthermore levels of resistance higher than those presently available are needed for most pests. Different combinations of resistances to diseases and insects are needed for different regions. Consequently, priorities for developing resistance to pest complexes will differ among regions of the Cotton Belt.

Sources of resistance to all major insects and diseases are available although many are in poorly adapted lines. These sources need to be combined into strains which are acceptable to farmers; then the combined potential of the traits may be

evaluated. Concurrent with combining resistant sources into a single strain, effective and efficient methodology for this process must be developed.

If all the presently known sources of resistance were incorporated into one variety, we would still need additional pest control methods to economically produce cotton. Experience from other crops has also taught us that pests can develop resistance or escape mechanisms to genetic sources of resistance. It is, therefore, evident that the search for more resistant genes and techniques to detect these genes needs to continue.

Efficient breeding for host plant resistance requires a thorough understanding of the inheritance of resistance. The co-relationship of resistance of one pest with resistance to other pests, agronomic, and quality characteristics need to be established to develop efficient breeding strategies. Inheritance of the many new traits as well as the co-relationships between resistance traits and performance traits must be ascertained. Finally, an optimum production program to effectively utilize host plant resistance to pests should be a component part of this research area.

New strains of pests that are more virulent or aggressive continue to appear and become predominant in cropping areas. For example, the defoliating strain of *Verticillium dahliae* was unknown prior to 1930 but now occurs throughout the Cotton Belt on nearly every farm in large cotton growing areas of the Texas High Plains, the Upper Rio Grande Valley, California, and the Mississippi Delta. We need to know more about the genetic variation of virulence and aggressiveness in pests, especially in regard to developing host resistance that is horizontal and less likely to be overcome by new races.

Plant genetics can be used to alter populations of beneficial organisms as well as pathogens. Recent evidence indicates that multiple pest resistance in certain varieties is associated with their greater ability to support populations of bacteria antagonistic to pests. This approach to increasing cotton resistance to pests is very promising and deserves thorough investigation.

Effective weed control in cotton requires combinations of cultural practices, herbicides and highly competitive cotton varieties. At the present time, breeding for weed resistance is largely a matter of breeding for a vigorous efficient plant. Differences in crop varietal susceptibility to herbicides as well as to particular insecticides are well recognized. Attention should be given to utilization of such differences in plant breeding programs to develop cotton varieties resistant to some of the more essential pesticides. Some plant-pesticide interactions are modified by yet other pesticides and may enhance efficacy. These should be investigated.

Understanding the nature of resistance mechanisms may facilitate breeding for resistance. It may also allow production to be managed in a manner that optimizes the use of resistance. Studies should include chemical, histological, and biological investigations of the nature of resistance.

Team efforts involving the necessary disciplines will be essential in accomplishing the potential of using host plant resistance for improved cotton production. The recommendations that follow will demand team efforts.

4. Objective: Develop new and improved populations and breeding lines of cotton with increased resistance to pests (insects, diseases, mites and nematodes) and tolerance to essential pesticides.

5. Research Approaches:

   a. Develop new breeding technology and transfer multiple pest resistance into agronomically acceptable breeding stocks. Priority 1.

   b. Develop more efficient and effective screening and evaluation methodology to identify pest resistance in large populations and evaluate cotton germplasm for new sources of resistance. Priority 2.

   c. Determine inheritance and heritability of resistance to specific pests and co-relationships of this resistance with other desirable characteristics, including resistance to other pests. Priority 3.

   d. Determine the nature of resistance to pests and to pesticidal chemicals. Priority 5.

   e. Collect and maintain germplasm from diverse sources. Priority 8.

   f. Develop production programs to efficiently utilize lines with resistance to pests and to essential pesticidal chemicals. Priority 4.

   g. Determine the nature and extent of genetic variation for virulence and aggressiveness in pests and their potential for overcoming sources of plant resistance. Priority 9.

   h. Locate breeding stocks that support large populations of beneficial microorganisms and evaluate this relationship as a potential method of pest control. Priority 7.

   i. Locate breeding stocks with significant tolerance for specific herbicides and evaluate their utilization in developing cotton tolerant to such chemicals. Priority 6.

RESEARCH OPPORTUNITIES
FIBER QUALITY, PROCESSING AND END-USE

(Includes Portions of Research in Research Problem

Areas 307, 308, 405, 407, 501, 503, 705, and 709)

SITUATION

This section on Fiber Quality, Processing and End-Use deals with the multiplicity of interrelated technologies needed to develop a quality fiber, to measure the quality and to convert raw cotton fiber into useful consumer products. The fact that clothing and textiles are second only to food as absolute necessities for human existence emphasizes the importance of this area of technology.

Other farm groups at times have voiced criticism at the seemingly higher level of research attention applied to cotton compared with certain other farm crops. For instance, the Federally funded research on cotton for 1976 totaled $20.4 million. The farm product value for cotton in 1976 was $3.3 billion. Soybeans had a farm value in 1976 of $9 billion and a Federally funded research program amounting to a little over $7 million. However, if one looks at the value of the product the consumer gets rather than the farm value, this comparison is far different. The estimated total value of all consumer products made from cotton at the retail level is over $40 billion, whereas, the retail value of food products from soybeans amounts to only a little over $ 26 billion. This large spread in "value added" between the harvested farm commodity and the products consumers use reflects the high cost of converting fibers into the ultimate consumer products.

Private and public sectors both have research programs dealing with development of fiber quality and conversion of fibers into finished products. Except for the cotton industry itself and some plant breeding firms, most private sector research is now largely concerned with man-made fibers. University as well as textile mill research is now more often than not aimed at replacing cotton with a man-made substitute, either petroleum based or high energy consuming cellulosics. Also the level of State sponsored post harvest cotton research including quality measurement is modest compared to Federal programs, a situation which reflects the national rather than the local nature of the problems involved. This is substantially different than in cotton production research where many of the cotton producing States fund substantial programs aimed at local problems.

Since issuance of the last National Cotton Research Task Force Report in 1973, the rate of change in all fiber use technologies has continued to increase. The past 10 years have seen major shifts in

emphasis away from product innovation and productivity and toward increased concern for environmental quality, human health and safety. This reflected growing public concern for such matters, and as a consequence, increased regulatory action by Government.

Chemical finishing of cotton originated in the 1950's. Market interest in easy care/durable press properties for textiles peaked in the mid-1960's. This was followed in the late 1960's by a brief but intense interest in soil release properties which gave way in the early 1970's to a relatively long period of high interest in flame retardant properties as a result of CPSC regulation. Industry interest in flammability shifted sharply in 1977 away from children's nightwear and clothing. In the textile finishing industry attention is now sharply focused on problems of toxicity and workplace safety and on environmental problems caused by plant effluents. Reduction of energy consumed in dyeing and finishing of textiles is also an urgent necessity since the oil embargo of 1973.

A somewhat similar pattern is apparent in the yarn and fabric manufacturing sector. In the 1950's and 1960's, concentration on increased productivity in ring spinning pushed speeds to the limit of present materials technology. Foreign research resulted in development of open-end spinning, the first really new principle in yarn manufacturing since the advent of the spindle and whorl. During this same period, the cotton industry moved from hand to machine harvesting, resulting in a need for entirely new technologies for ginning and cleaning cotton. Mill processing continued to automate during the 1960's, and much of the innovative and productive capacity of textile machine builders moved to foreign countries. Automation and pressure for increased productivity from harvesting through fabric formation greatly multiplied the stresses on cotton fibers in these processes. The deficiencies in cotton fiber quality became apparent in the 1950's and was highlighted in the 1960's as U.S. cotton lost markets in North Europe to competing countries particularly the USSR. A regional test of high fiber quality cotton breeding lines was organized in 1964 which focused attention on the possibilities for improving cotton fiber strength and yield concurrently. Several private breeding firms have added publically developed high-fiber-quality germplasm to their programs but other recent concerns, such as cotton dust, have diverted attention from fiber quality. In the early 1970's, cotton dust was of no general concern, and the associated lung dysfunction, byssinosis, was a relatively unknown term. However, as a result of actions by Congress and OSHA, these now consume almost the entire attention of the cotton and cotton textile industries, and the end is not yet in sight.

The purpose in noting these major shifts in popular attention in the marketplace where cotton must compete is to emphasize that research, particularly basic research, to be meaningful must proceed by many months or years the advent of commercial interest or regulatory action. By the time any particular subject becomes of broad public interest, it is usually too late for any but the most applied of research solutions. Fortunately, in the past, a store of basic knowledge from earlier research has often been available to apply to the critical problems and opportunities as they appeared. However, this reservoir of knowledge

is mostly depleted and needs to be refilled. It is hoped that future needs of cotton consumers can be recognized far enough ahead so that essential basic and exploratory research can be directed well in advance of critical need.

There is little doubt that safety, health and environmental concerns will continue to hold the cotton spotlight for some time to come. In particular, problems associated with cotton dust, improved fiber cleaning and elimination of all health hazards associated with cotton processing are the most urgent of all. In fact, the future of a cotton industry in the United States depends on successful solutions to these problems. Many of the technologies covered in this area, from plant breeding through textile finishing, impinge on or directly relate to the health concern which is treated in another section. However, there is growing evidence that the need for increased innovation and productivity in the Nation's manufacturing and delivery system is beginning to be recognized by Government. Research for cotton should be redirected toward these new goals including improvement of the raw fiber quality and the measurement of the quality to determine the most appropriate use and processing specifications.

The major long-range threat to continued use of agricultural staple fibers is the steady use of continuous filament man-made fibers which have the potential to bypass completely the yarn manufacturing stage essential to staple fibers. The chemical fiber industry is working diligently and successfully on texturizing and other treatments for filament yarns to provide the appearance and aesthetics of natural fibers at much lower cost. It is essential for cotton to develop completely new methods for producing yarns and fabrics from staple fibers at much lower cost and to develop the qualities of staple fibers necessary for successful implementation of these new processes if this part of agriculture is to survive and consumers continue to have a choice.

SPECIFIC RESEARCH ACTIVITIES

A. Fiber Quality Improvement

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	1.0	0.9	1.9	307
	6.8	0.1	6.9	405
	1.4	0.0	1.4	407
	0.0	1.5	1.5	501
No Increase	1.0	0.9	1.9	307
	8.2	0.1	8.3	405
	0.0	0.0	0.0	407
	0.0	1.5	1.5	501
20% Increase	1.2	1.0	2.2	307
	9.8	0.1	9.9	405
	0.0	0.0	0.0	407
	0.0	1.5	1.5	501
Recommended	2.5	1.0	3.5	307
	7.0	0.1	7.1	405
	0.0	0.0	0.0	407
	0.0	1.5	1.5	501

2. Priority: 6

3. Situation: The use of cotton as a raw material for textiles predates recorded history. Through the centuries cotton has had a significant role in the agriculture, commerce, and industry of the world. Traditionally the quality of cotton has been evaluated by (1) grade, which takes into account color and cleanliness, and (2) staple, which is a measure of the length of the fibers.

   These properties were measured by eye and hand in marketing and to some extent by breeders. Today, particularly in support of breeding objectives, instruments have been developed to measure length, strength, fineness, color, and elongation (extensibility) of fibers, as well as properties of yarn from miniature spinning samples. The range of genetic variability in these properties is wide.

   Quality may be defined as "fitness for use," and specifications suitable for specific end uses are bred into varieties. Quality also has an "efficiency of processing" aspect, so quality is that set of properties which allows the fiber to be processed efficiently and produce a satisfactory end-product.

Modern textile mills are demanding cotton with improved raw cotton specifications. The advent of man-made fibers, blends, chemical treatments, and the development of new processing systems, as contrasted with traditional ring spinning, makes it necessary to constantly redefine quality in view of the realities of processing and marketing. The raw cotton properties influencing ease of processing and serviceability of finished product are, to a considerable extent, known for ring spun cottons. Fiber properties required for open-end and other spinning systems are poorly defined.

Fiber properties of Upland cotton produced in the United States vary in length from approximately 7/8 inch to 1-1/8; 1/8 inch gauge bundle strength from 170 to 280 mN/tex and above, and micronaire readings from 2.5 to 5.5. Pima cotton fiber is longer, stronger, and finer, averaging 1-3/8 inches, 300 mN/tex, and 3.6 micronaire units. The characteristics of cotton fiber vary considerably within and among geographical zones of the Cotton Belt. Mean fiber properties, based on the National Cotton Variety Testing Program, are as follows:

Fiber Properties of Typical Varieties Grown in Each Zone.

Zone	Fiber Properties 1/		
	Length in.	Bundle strength mN/tex	Micronaire reading
Upland			
Southeastern	1-1/8	185	4.4
Midsouth	1-3/32	185	4.7
Texas High Plains-Oklahoma	1	180	4.3
Trans Pecos-New Mexico	1-3/16	220	4.1
Western	1-1/8	230	4.3
Pima	1-3/8	290	4.0

1/ Fiber properties from Results of Regional Cotton Variety Tests, ARS 34-130, S-33, and S-62, 1970-72.

Southeastern Zone: Cotton produced in the Southeast has fiber length and strength less than that desired for present textile requirements. Recent developments in breeding research have increased fiber length. Fiber strength is still below the desired level although breeding lines with increased strength were released in 1974 and 1975.

Midsouth Zone: Cottons from this zone have been used in large amounts in consumer products. Presently no varieties adapted to this zone possess all the desired quality values and fiber strength needs to be increased.

Texas High Plains-Oklahoma Zone: At least 60 percent of the production has fiber length and micronaire so low that present markets are limited; however, the fiber can be used in specific products such as denim and corduroy.

Trans Pecos-New Mexico and Western Zones: Quality characteristics of varieties predominantly grown in these zones exceed those of other Upland zones. However, sizable variations exist in quality within the zone.

Pima Zone: The longest, strongest, and finest fiber in the U.S. is produced in this zone. Extra-long staple cotton is used primarily for thread and other high-quality textiles. The major breeding effort is for increased yield while maintaining or slightly improving fiber quality.

The textile industry has utilized blends of man-made fibers and cotton to meet requirements in end products. The supply of specific quantities produced in the different zones is sufficient to meet demand but changes in the type produced in one zone without concomitant changes in other zones could have serious impact on the supply situation. The differential in quality levels among the zones should be maintained to provide for orderly marketing.

Fiber evaluations: Instruments have been developed to accurately measure length, length uniformity, tensile strength, and fineness of cotton fibers. Past research has resulted in development of miniature spinning techniques that make possible the production and evaluation of yarn from 50-gram samples of cotton.

Traditional classers' methods of grading and current test instrument systems both evolved in response to the needs of the traditional ring spinning system of yarn production which still predominates throughout the world. Productivity by this route has reached a limit, and in the past 5 years open-end spinning, a system based on new principles of fiber assembly, threatens to supplant ring spinning at least for the coarser yarn counts. "No twist" yarn manufacturing systems involving adhesives rather than twist are being developed. Electrostatic and fluid vortex forces are being explored for introducing twist in yarns. Non-woven fabrics are being produced by both dry and wet lay methods of fiber assembly. Greater attention is being paid to safety and health of workers. Blends of cotton with other fibers have taken over many traditional 100 percent cotton markets. Knowledge of structural, chemical, and surface properties of fibers is important for developing the properties needed in products to meet consumer demand. It is important to identify and measure fiber characteristics needed to satisfy these new technologies as they become commercially significant.

4. Objectives:

   a. Identify raw cotton properties that contribute to improved processing and improved yarns and fabrics. Priority 1.

   b. Develop cottons with improved fiber quality. Priority 2.

5. Research Approaches:

   a. (1) Determine the relationship between raw cotton properties and the efficiency of processing by ring, open-end and other techniques and end product performance.

      (2) Describe growth and development of cotton fibers.

      (3) Determine developmental patterns and genetic and environmental control of cotton fiber.

      (4) Determine contaminants in raw cotton that may affect processing such as dust or additives and develop measurements for these substances.

   b. (1) Develop breeding techniques and breeding lines and varieties combining improved fiber quality with optimum yield, improved seed quality, and more desirable agronomic properties.

      (2) Evaluate fiber and spinning properties of material in breeding programs for monitoring effectiveness of breeding systems and modify fiber and spinning test procedures for more rapid and accurate determinations of quality.

      (3) Determine the relationships of raw cotton properties to spinning performance and adaptability of genotypes to environments.

B. Fiber Quality Measurement

1. SY Situation:

Support level	Number of SY's			RPA
	SEA-AR	SAES	Total	distribution
Current	5.3	0.0	5.3	501
	1.1	0.0	1.1	308
No Increase	5.3	0.0	5.3	501
	1.1	0.0	1.1	308
20% Increase	6.4	0.0	6.4	501
	1.3	0.0	1.3	308
Recommended	5.7	0.0	5.7	501
	1.2	0.0	1.2	308

2. Priority: 4

3. Situation: The U.S. Cotton Crop in recent years has varied in value from \$1.5 to \$3 billion, depending on yield and selling price. It is a vital agricultural commodity. The value of the crop, and consequently utilization, is based on its quality, the efficiency of marketing, and its adaptability for various end-uses. The Agricultural Marketing Service (AMS) is responsible for classifying the U.S. Cotton Crop. During the past 13 years, 35 percent of the crop has been exported. Domestic and export cotton is classified using the same procedures and standards. Primarily, grade, length of staple, and micronaire reading are used to describe the quality of cotton for the first marketing stage. Length of staple is a subjective measurement determined through the highly developed skill of the cotton classer. Grade is determined by averaging the three factors, color, trash, and preparation which are determined subjectively. Therefore, grade and length of staple are highly susceptible to personal influence as are other sensual measurements. Color and leaf are integrated into one quality designation for marketing which confounds interpretation. Fiber length uniformity is considered a part of the staple measurement so that these two factors are also confounded. Fiber strength, a major fiber property, is not even considered in the classification system. Significant technological progress in fiber utilization has been made since the classification system was originally instituted. Changes in the system have not kept pace with changes in the industry. Grade and staple determinations for cottons from different growing locations do not have the same meaning to users. For example, cotton from the Southeast that is classified as Strict Low Middling 1-1/16 inch staple does not perform the same in manufacturing as cotton from the far West with a similar quality classification. It is common to find users purchasing cotton from farmers or brokers on the basis of grade and staple or their own types and then testing the cotton on laboratory instruments to determine how to use it efficiently in mills. Testing instruments developed for use in laboratories provide quality measurements more highly related to use value and more consistent with actual fiber quality than the current classification system provides. Technology is available for developing an instrument classification system that is superior to systems now in use Potential for even greater superiority exists through improved specimen preparation devices, color and trash measuring devices, development of chemical tests and in the development of an engineering basis for the market quality determination through pilot plant spinning evaluations.

   The subjective determination of cotton quality as represented by classers' grade and staple can be replaced with measurements by instruments developed for rapid determination of fiber properties important to use value. It can be done with little or no change in total cost and can provide more reliable information necessary for marketing and efficient mill operation. It will allow cotton to be traded on specifications, will greatly enhance cotton's competitive position in the fibers market, and will facilitate quality maintenance.

Work should be conducted in two major areas concurrently: (1) instrument development for measuring physically and chemically, the properties of cotton that are related to use value; and (2) spinning quality evaluations to provide the basis for the development of relationships between market quality and the relative value of different cottons. Instrument development work should concentrate on fiber property measurements currently accepted by the cotton industry as useful in the marketing and utilization of cotton. Within 5 years at current research levels, the prototype testing system now under evaluation can be developed and sufficiently refined to adequately test the cotton crop for properties currently considered important. At that point effort can be redirected toward the search for other fiber characteristics that will allow more precise description of cotton quality for specific end uses. This will provide engineering specifications for use in cotton marketing as they are used in marketing man-made fibers and will require an additional 3 to 5 years. Spinning quality evaluations on conventional equipment will be performed to establish specific engineering relationships necessary to construct the framework of a marketing system based on objective instrument measurements rather than subjective measurement now used. Similarly, spinning quality evaluations on newly emerging systems, such as open-end spinning and twistless spinning, will be necessary to provide guidance to breeders, producers, and ginners in changing to the new spinning technology.

Furthermore, changes in textile technology now occurring are creating marketing problems for cotton. Increased demands for cleaner cottons because of problems with rotor deposits in open-end spinning and with cotton dust in all processing areas threaten to eliminate the improvements in market quality achieved at great expense and effort during the past 10 years. Excessive cleaning and drying, known to be detrimental to fiber length, are being used in attempts to reduce the trash and dust content of cotton. Finally, the effect on market quality of the SEA research program on cotton breeding, production, and harvesting must be evaluated on a continuing basis. Economic pressure is causing changes in production and ginning procedures that affect quality. Significant effort will be required to assure market quality maintenance throughout the planning period.

4. Objectives:

   a. Produce an efficient system of testing instruments for use in cotton classification and marketing. Priority 1 (equal to b).

   b. Develop spinning procedures and conduct spinning studies using conventional and other commercially promising systems to develop relationships suitable for use in establishing the relative market value of cottons with different fiber properties. Priority 1 (equal to a).

5. Research Approaches:

a. (1) Using presently accepted measurements of length, length uniformity, strength, fineness, color, and trash, develop, through laboratory experimentation and contracts with manufacturers, prototype instrument systems for use in cotton classing offices and in general cotton marketing.

(2) Identify and evaluate other cotton quality factors, using physical and chemical methods, that contribute to the market and use value of cotton, and incorporate measurements of these factors into the system devised in (1).

b. (1) Develop spinning quality evaluation procedures for most efficient use of the natural attributes of the cotton fiber.

(2) Use the procedures developed in (1) to provide for relationships necessary to devise an improved classification and standards system for efficient marketing of cotton on the basis of fiber properties truly related to use value.

(3) Perform quality evaluations to determine the effects of production, harvesting, and ginning practices on fiber and spinning quality and the use value of cotton.

C. Harvesting, Ginning, and Fiber Preparation

1. SY Situation:

	Number of SY's			RPA
Support level	SEA-AR	SAES	Total	distribution
Current	6.5	0.0	6.5	308
	9.5	0.0	9.5	407
	1.5	0.0	1.5	503
	0.5	0.0	0.5	709
No Increase	6.5	0.0	6.5	308
	9.5	0.0	9.5	407
	1.5	0.0	1.5	503
	0.5	0.0	0.5	709
20% Increase	7.8	0.0	7.8	308
	11.4	0.0	11.4	407
	1.8	0.0	1.8	503
	0.6	0.0	0.6	709
Recommended	7.8	0.0	7.8	308
	11.4	0.0	11.4	407
	1.8	0.0	1.8	503
	0.6	0.0	0.6	709

2. Priority: 1

3. Situation: The relatively high levels of trash and dust in machine harvested cotton directly affect production costs, ginning costs, and mill performance. Research is being conducted to improve trash removing machinery. However, the respiratory problems in mill workers recently associated with cotton dust complicates the competitive position of cotton and adds emphasis to needs for improved trash removal systems in the field and gin.

   The mechanical process of separating fibers from seed, known as ginning, is the first in a long series of processing steps through which the fiber passes on its way to the consumer. Ginning also involves considerable pre-cleaning and separation of plant trash from the seed cotton. Further, the traditional grading and marketing system requires considerable cleaning of the lint cotton, a process which begins in the gin and continues throughout the early stages of textile mill processing. It is conceivable that some of the early stages of mill processing, possibly including carding or combing, could be more efficiently carried out by the gin. The several steps in ginning and baling cotton include (1) materials handling and collection; (2) seed cotton conditioning; (3) seed cotton cleaning and extracting; (4) lint-seed separation; (5) lint cleaning; and (6) packaging. With the cost-price squeeze on cotton production and the competition with synthetics, there is a continuing need for further cost reduction and quality preservation in the ginning process.

   Ginned cotton lint as received by the textile mill undergoes a number of sequential processing operations preparatory to conversion into yarn or non-woven product. The basic processes are: (1) additional cleaning to remove remaining plant trash and short tangled fibers; (2) fiber-to-fiber separation; and (3) formation of a continuous uniform sheet or attenuated strand of fibers. Cleaning and short fiber removal are added cost factors for cotton compared with synthetics, which arrive at the mill door in a clean uniform condition. Traditional mill operations in preparation for conventional yarn manufacture include opening, picking, carding, combing, drawing and roving. During the past 10 years major progress has been made in increased efficiency and throughput of preparatory operations; but because of rising labor costs, increased productivity has often been offset by reduced product quality. Continued research is necessary to develop new methods and equipment for improved cleaning and ultimate product quality while maintaining efficiency by maximum use of automated operations. USDA (SEA-AR) now has under development a novel system of fiber preparation which, when fully developed, will eliminate the separate operations of picking, carding, drawing, and roving. Fiber tufts from the opening operation are fed at one end of the device and a uniform flow of individualized, cleaned fibers is delivered at the other end ready for spinning. As a completely integrated system, the unit can be enclosed and kept under

slight negative pressure to prevent escape of dust into the working atmosphere. The rapid acceptance of open-end spinning has emphasized the need to remove fine dust which otherwise accumulates and interferes with the spinning operation. Modification of existing equipment or development of new machinery capable of removing essentially all of the trash and dust is urgently needed if cotton is to maintain and improve its present position.

4. Objectives:

   a. Develop new and improved harvesting and handling methods that reduce foreign matter content, reduce costs, and maintain the inherent quality of cotton. Priority 4.

   b. Develop and evaluate more effective and efficient methods of conditioning, cleaning, ginning, and packaging cotton, thereby enhancing quality and value, reducing costs, and lowering cotton dust levels. Priority 2.

   c. Develop machinery, processes, and systems to more efficiently and effectively remove or control trash and dust from cotton fibers in pre-yarn-formation operations. Priority 1.

   d. Develop automated systems and characterize fiber, process, and yarn variables involved in reducing the processing steps in preparing yarn and webs from fiber. Priority 3.

5. Research Approaches:

   a. (1) Investigate and develop new technologies that will prevent contamination of seed cotton with trash.

      (2) Investigate and develop new types of cotton harvesters, components, and attachments that reduce trash and moisture content and perform additional processing operations in the field.

      (3) Develop more efficient moduling, storage, handling and gin feeding equipment and procedures that preserve fiber qualities, and reduce moisture, trash, and dust problems.

      (4) Develop more dependable defoliation methodologies.

   b. (1) Quantify and optimize the interrelated effects of varietal, cultural, harvesting, and ginning practices on physical properties of cotton and their relation to processing costs and end use-value and performance.

      (2) Develop and evaluate handling and processing equipment and procedures for technologies with potential for alleviating the cotton dust problem.

(3) Develop automated process control technology for conditioning and cleaning seed cotton and lint for optimized cotton quality and producer returns.

(4) Develop lint packaging equipment and systems for improved efficiency and preservation of fiber quality during storage, handling, and shipment.

(5) Develop improved equipment and methods of cleaning seed cotton and lint to improve ginning efficiency and meet requirements for end-use processes.

(6) Develop improved and more efficient seed cotton and lint moisture conditioning equipment and procedures for preserving fiber use value and optimizing producer returns.

c. (1) Develop methods to measure/predict the dust potential of a sample/lot of cotton.

(2) Optimize the use of additives and explore other technologies, such as washing or gaseous deactivation, for controlling/eliminating cotton dust exposure in textile mills.

(3) Apply pneumatic, sonic, electrical, and mechanical forces to individualize fibers and separate trash and dust from fibers.

(4) Determine relations among production, harvesting, ginning, and pre-yarn-formation processes and their single and combined effects on reducing trash and dust levels.

d. (1) Develop, optimize, evaluate a continuous fiber preparation system for supplying from tufts, multiple outputs, each having a uniform flow rate of opened fibers suitable for open-end spinning.

(2) Develop and evaluate electrostatic methods for fiber transport and spinning.

(3) Investigate wet processing methods for opening, blending and aligning fibers.

(4) Determine the relations among fiber properties, sliver quality, processing and spinning variables, and open-end spun yarn properties.

D. Conversion to Yarns and Fabrics

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	8.1	0.0	8.1	407
No Increase	8.1	0.0	8.1	407
20% Increase	9.7	0.0	9.7	407
Recommended	9.7	0.0	9.7	407

2. Priority: 2

3. Situation: Textile mill operations today still utilize 10 to 15 individual, discontinuous processes and an excessive amount of labor. Even where existing machinery has been coupled into a semicontinuous system, processing costs remain about half the selling price. Open-end spinning and conventional equipment improvements are being investigated but there is as yet only a limited effort by the industry to develop a complete and continuous system to process raw cotton into yarn or fabric.

The price advantage and minimum processing requirements of man-made fibers have influenced the textile industry to use cotton/man-made blends in increasing quantities. Presently, most blended products contain higher levels of man-made fiber than cotton, and machine settings and speeds generally are not directed toward efficient cotton fiber processing. The limited use of cotton in knitted fabrics is especially apparent. There is much evidence that cotton's inherent desirable properties can be better utilized in high level cotton fiber blends. The use of wool as a blending fiber also presents opportunities for end-products with unique properties. Additionally, present techniques for fiber blending have certain inherent disadvantages which result in non-homogeneous fiber blending. The stringent new rules issued by OSHA, on June 19, 1978, to reduce worker exposure to cotton dust impose an additional constraint on the textile industry. Reduction or elimination of cotton dust in the mill environment while maintaining standards of quality must be an integral part of the improved processing technology.

Research to reduce costs while improving quality in 100 percent cotton and high cotton/man-made blend fabrics is essential to meet the increasing competition from man-made fibers. These objectives can be achieved through research in these major areas: (1) improving existing processing techniques and developing fundamentally new processing systems for cotton and cotton/man-made fiber blends; (2) developing suitable processing equipment and techniques to improve the quality of cotton

blends with other fibers; and (3) devising acceptable techniques to reduce or eliminate the cotton dust in processing areas.

4. Objectives:

To translate the inherently excellent fiber qualities of cotton into high-grade product qualities at reduced processing cost by developing and/or determining:

a. Additive treatments for fibers or intermediate products preceding or following spinning. Priority 7.

b. The relation of fiber properties to the physical properties of "open-end" spun yarns and to spinning efficiency. Priority 4.

c. Cotton and cotton blend knitting yarns with improved functional characteristics. Priority 6.

d. New equipment for altering fiber cohesion to improve cotton yarn properties and cotton/man-made blending efficiency. Priority 3.

e. Improved methods for removing dust, trash, and neps from lint cotton. Priority 5.

f. Fundamentally new systems for processing cotton textile fibers in a continuous system from the bale into the yarn. Priority 1.

g. Systems to process cotton with minimum dust generation. Priority 2.

5. Research Approaches:

a. (1) Apply chemical compounds, affecting surface cohesive characteristics of fibers, in intermediate processes prior to spinning to improve spinning performance.

(2) Modify sizing techniques to improve knitting and weaving operations.

b. (1) Correlate fiber properties with product quality and processing efficiency using commercially available "open-end" spinning frames.

(2) Devise methods to improve functional properties of open-end spun yarns.

c. (1) Develop improved cotton blend fabrics containing wool and other fibers.

(2) Develop cotton knitting yarns with improved strength, toughness, smoothness, uniformity, and resistance to linting and fuzzing.

(3) Determine the effects of various yarn and fabric structure parameters on knitted fabric properties both before and after chemical finishing.

d. (1) Develop new techniques and equipment for more efficiently processing cotton and for producing more homogeneous cotton man-made fiber blends.

(2) Develop techniques for producing "no twist" cotton yarn.

e. (1) Develop equipment for completely removing dust, trash, and neps from lint cotton using aerodynamic and electrostatic forces.

f. (1) Develop a prototype prespinning fiber preparation system for processing cotton from the bale into yarn in a continuous system.

(2) Develop methods for manipulating individualized fibers in electrostatic and magnetic force fields.

(3) Study mechanical processing variables for efficiently processing intermediate products produced from experimental prespinning machinery.

g. (1) Characterize cotton-related dust and develop innovative techniques for its removal from mill environments.

E. Conversion to Finished Products

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	4.9	0.0	4.9	407
No Increase	4.9	0.0	4.9	407
20% Increase	5.9	0.0	5.9	407
Recommended	5.9	0.0	5.9	407

2. Priority: 5

3. Situation: Research on techniques for applying chemicals and finishes to cotton fabrics is required to make cotton more competitive with man-made textiles and to make new and useful products available. This need must be met by the generation of fundamental knowledge as well as by innovative adaptation of basic science and promising advances from other fields of chemistry and engineering. Cotton fabrics require purification as well as finishing for specific end-use properties. By contrast, synthetic fabrics are supplied as the purified fiber with specialized end-use properties built into the textile polymer. Thus, finishing processes and techniques are much more important for cotton product manufacture than for synthetics.

   Conventional cotton finishing is based largely upon the wetting of fabric with dilute aqueous solutions and thermal evaporation of the large quantities of water retained on the fabric. Such processing is wasteful in terms of energy and water usage (see related energy and pollution areas in this report). These factors emphasize the need and opportunities for the development of alternate techniques for finishing fabrics.

4. Objectives:

   a. Develop more efficient fabric preparation and mercerization methods and determine the influence of these process variables on the effectiveness of subsequent finishing treatments.

   b. Develop methods for finishing wet fabrics or for finishing with minimum add-on of solutions of chemicals.

   c. Develop finishing treatments to impart improved functional properties to textiles through utilization of ultraviolet, electron beams, or other radiation curing processes.

   d. Develop methods for controlling the location and uniformity of a chemical modification of fabric.

   e. Develop an overall systems approach to maximize end-product performance by considering yarn and fabric structure, fabric distortions and changes caused by chemical finishing.

5. Research Approaches:

   a. (1) Investigate in-depth scouring and bleaching to evaluate available chemical options and their influence on fiber performance.

      (2) Investigate conditions and discover additives for increasing the rate of mercerization using caustic or liquid ammonia.

(3) Develop an understanding of the interaction between preparation and mercerization on one hand and subsequent chemical finishes so as to maximize the benefits achievable from mercerization.

b. (1) Develop information in foam chemistry so that a better understanding is available for using these materials in finishing.

(2) Study transfer printing systems to broaden the range of dyeing and finishing operatings that can be performed using this technique.

(3) Investigate non-aqueous and vapor phase systems for dyeing and finishing of cotton fabrics.

c. (1) Investigate polymerization systems using radiation curing processes on cellulosic fabrics with a view of improving efficiency.

d. (1) Study migration of chemical agents on fabrics so that that role of migration in the location of chemical modification on fabric can be understood.

(2) Use transfer techniques to selectively apply chemical reagents to various regions of fabrics as a means of controlling the site of reaction on fiber, yarn, or fabric.

e. (1) Investigate the interactions between yarn and fabric structures, preparation techniques, fabric stresses caused by processing, and chemical changes caused by finishing.

F. End-Use Properties and Products

1. SY Situation:

	Number of SY's			RPA
Support level	SEA-AR	SAES	Total	distribution
Current	20.0	0.1	20.1	407
	0.0	0.1	0.1	705
	3.6	0.0	3.6	709
No Increase	20.0	0.1	20.1	407
	0.0	0.1	0.1	705
	3.6	0.0	3.6	709
20% Increase	24.0	0.1	24.1	407
	0.0	0.1	0.1	705
	4.3	0.0	4.3	709
Recommended	24.0	0.1	24.1	407
	0.0	0.1	0.1	705
	4.3	0.0	4.3	709

2. Priority: 3

3. Situation: More than any other textile fiber, the cotton fiber has a wide range of attractive physical properties, a balance of esthetic qualities, and an amenability to chemical modification for alteration of performance properties. Natural attributes of cotton include strength, elasticity, warmth, drape, hand, color fastness, and comfort. Desirable properties for apparel in present and future markets require durable-press or easy-care performance as a basic characteristic together with improved wear life. Durable-press performance, although readily achievable in cotton fabrics, carries along certain undesirable results, that require corrective attention; these include strength loss, lowered abrasion resistance, reduced comfort, and decreased soil release. Easy-care performance should be supplemented with a variety or multitude of performance properties desirable to the industrial worker or private consumer, e.g., flame retardancy, soil resistance, antimicrobial activity, and water repellency. Some of these latter properties are especially useful for penetrating and retaining markets other than in the apparel field, as, for example, for outdoor and industrial uses where durable-press or easy-care performance may not be required. New performance features for new uses such as for medical and dental accessories and surgical uniforms, include highly hydrophilic cottons with good strength, oil resistance, resilience, and soil release properties. For most of the end-use properties and products noted above there are various possible modes of application of agents to fabrics. Some of these modes are well-known but require reduced odor and toxicity of agents; other modes hold promise of improved properties and products. Two modes that offer substantial promise in these regards are minimum application methods and vapor phase treatments; these require in-depth studies to relate reaction mechanism, location of reagent residues, and performance qualities. Research directed toward improving the fore-going end-use properties would result in: (a) greater durability in apparel and household fabrics; (b) increased consumer satisfaction from more comfortable and aesthetically attractive textile products; (c) multi-purpose finishes for textile fabrics that meet the requirements of work, leisure, household, and industrial markets; (d) savings resulting from higher quality products from products that are more easily cleaned with reduced energy requirement for laundering and from greater ease of cleaning garment maintenance due to longer, dirt-free, microbe-free service life of fabrics; (e) new consumer products with new service qualities; and (f) increased consumer use of cotton products.

4. Objectives: Increase the usefulness, desirability and efficiency of production of cotton textiles through:

   a. Characterization of subfiber elements in native and chemically modified cotton celluloses and establishment of their relation to finishing reactions and performance properties. Priority 4.

b. Clarification of mechanisms whereby high levels of strength and abrasion resistance can be combined with high levels of durable-press performance to develop chemical reagents or finishing systems suitable for achieving high performance durable-press cottons. Priority 2.

c. Elucidation of the mechanisms by which flame retardants are effective to develop more efficient flame-retarding systems for cotton. Priority 5.

d. Develop substantially new finishing systems to achieve cotton products having high levels of combined consumer or industrially-oriented properties such as durable press, flame retardance, enhanced comfort, antibacterial activity, antiviral properties, soil repellency, soil release, absorbency, etc. Priority 1.

e. Development of means of achieving low odor, low toxicity levels and route to chemical reagents and processes for imparting desirable consumer properties. Priority 3.

5. Research Approaches: (In priority order within objective)

a. (1) Investigate differences in microstructural features between high and low performance cotton fabrics, and relate differences to individual physical properties.

(2) Distinguish features of the microstructure of the cotton fiber and substructures of the cellulose fibril as related to penetrability and diffusion of reagent molecules and to physical properties of the cotton fiber.

(3) Explore microstructural features and chemical fixation of cotton fibers in the biological never-dried state as a means of understanding and preserving the unique tensile and sorptive properties of these fibers.

b. (1) Study migration of reagent systems into cotton fabrics, yarns, and fibers in relation to performance qualities of finished fabrics.

(2) Identify the factors that control the ability of water-soluble finishing reagents to penetrate cotton.

c. (1) Explore opportunities for synergistic interactions among flame-retarding reagent systems to achieve increase effectivensss of the agents at substantially reduced consumption of chemicals for cotton apparel and industrial fabrics.

(2) Correlate composition and structure of various flame-retarding systems with pyrolysis characteristics and fuel forming propensities of the treated cotton fabrics.

d. (1) Investigate selected new polymerization-crosslinking reactions in cotton for achievement of high performance durable-press cottons and combinations of high performance durable press with other consumer properties.

(2) Explore new chemical modifications and finishing reactions of cotton for improved combinations of durable-press, comfort, strength, soil release, flame retardancy, antimicrobial activity, weathering resistance, and other desirable performance properties.

(3) Explore chemical modifications of cotton to achieve high levels of hydrophilicity of treatments involving steps such as swelling, plasma activation, and deposition of selected reagent or polymer residues.

e. (1) Develop detailed knowledge and understanding of the critical parameters involved in vapor-phase finishing of cotton fabrics for various performance properties.

(2) Investigate routes to odor-free, formaldehyde-free, highly reactive reagents of low or negligible toxicity.

RESEARCH OPPORTUNITIES
SEED QUALITY, PROCESSING, AND END USE

(Includes Portions of Research in Research Problem

Areas 208, 307, 308, 309, 405, 406, 408, 501, and 702)

SITUATION

Cottonseed is a valuable source of protein and oil, and important industrial segments have developed around the use of cottonseed for oil, livestock feed, and other specialized products including food. However, the biological linkage of cottonseed and fiber has resulted in cottonseed being considered as a by-product of the economically more valuable fibers. Because of this fact and the historically uniform oil and protein content of seeds little research has been done on the genetic improvement of cottonseed quality; research has primarily centered on utilization and product development of the cottonseed as essentially a uniform product.

Research on planting seed has suffered a similar fate, especially that directed to the genetic improvement of quality. Breeders have recognized the need for good quality planting seed, and have directed their efforts primarily at maintaining quality by the elimination of undesirable types rather than toward programs to improve quality.

Gossypol has been a major deterent to the expansion of cottonseed into the nonruminant feed and human food market; other nonnutritive substances such as the flavonoid pigments have also affected food-use of cottonseed products. The relatively recent development of the genetic potential to eliminate, reduce, or raise gossypol concentrations in the seed, and the ability to reduce mechanically the quantities of glands and gossypol in the processing of cottonseeds to food-grade products heightened an awareness of the potential, as well as the problem of cottonseed quality. Moreover, the chemistry of quality cottonseed needs to be related to processing variables that affect end-use quality of cottonseed products. Strong competition in the food market exists in development of cottonseed products as food ingredients depend upon efforts to characterize, interrelate, and utilize their unique physiochemical, functional, and nutritional properties.

Many interlinking steps must be completed before glandless seeds will be produced and used on a large commercial scale. The economic and social pressures that will determine when these events will take place are not a subject of research, but the certainty that these events will occur requires that we study cottonseed quality so that future challenges can be met. Even for current uses of cottonseed, we have an inadequate

understanding of how the seed develops, how to measure factors that are important in determining preferred quality, and the extent to which we can modify genetically the quality factors.

Governmental regulation of internal and external pollution, constraints on energy use, and inflation is causing an immediate economic impact on the cottonseed industry. These factors are requiring the industry to revamp existing, or develop new, facilities with equipment and procedures for which, in many cases, the information or technology is not available to meet these demands. The urgency of these demands requires that avenues of communication must be developed between scientists, industry, and governmental regulatory agencies to encourage development of research programs, study ways of controlling pollution and energy, and allow dissemination of information on implementing and maintaining technological breakthrough.

In this report opportunities for research on cottonseed are separated into the requirements for producing quality cottonseeds, the preservation of seed quality, and the processing and utilization of seed. Distinction is not made between planting and industrial processing seed quality because it is felt that most factors that will insure desirable quality of planting seed will have a desirable effect on the preservation of total seed quality.

Although the research opportunities are separated into specific discipline-research and RPA areas as a means to readily identify research needs, we recognize the need for a coordinated and integrated research approach to seed quality. We have attempted to identify factors important for good seed quality; and the need for methods to measure these factors both analytically and for routine evaluation. Research approach priorities are directed at filling in informational gaps and provide the basis for coordinated research activities to proceed from cottonseed improvement to final products.

SPECIFIC RESEARCH ACTIVITIES

A. Production of Quality Cottonseed

1. SY Situation

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	0.0	0.1	0.1	308
	0.2	0.0	0.2	309
	9.3	0.1	9.4	405*
No Increase	1.8	0.6	2.4	308
	0.1	0.0	0.1	309
	6.9	0.1	7.0	405*
20% Increase	1.8	0.6	2.4	308
	0.1	0.0	0.1	309
	6.9	0.1	7.0	405*
Recommended	2.2	0.7	2.9	308
	0.1	0.0	0.1	309
	8.3	0.1	8.4	405*

*Part of this research is listed as RPA 307 and 406, but it is felt that it is most appropriately classed as 405.

2. Priority: 1

3. Situation: Except for gossypol, little genetic variation for seed quality traits among cotton varieties has been identified. Thus, only traits identified with current breeding lines can be subjected to genetic modification. Moreover, knowledge of genetic control of these traits is practically nonexistent; research is needed in this area to enable breeders to modify quantity and quality of stored constituents of seeds. Extensive collections of *Gossypium* germplasm are available and should be screened for desired genotypes for seed composition. Basic genetic and cytogenetic research and development of breeding methodology and techniques should be intensified to permit maximum examination and utilization of available germplasm to develop lines of cotton having select seed quality traits. Private cotton breeding firms have assumed the major responsibilities for providing improved varieties in the United States. However, public agencies must provide help to identify and develop improved seed quality germplasm that can be included in varietal improvement programs.

   The ability to do research on seed composition or to manipulate genetically these factors in segregating plant populations depends upon availability of appropriate methods for their measurement. Increased levels of oil and protein and reduced levels or the absence of seed gossypol are readily identifiable

goals for improving seed quality. The reduction or elimination of cyclopropene fatty acids as well as factors that reduce or eliminate microorganism contamination are desirable quality factors for food and feed. A reduction in seed coat permeability has been proposed as a desirable factor to preserve seed quality both for planting seed and processing. Methods are needed for accurate measurement and screening of the identified quality parameters and for new traits as they are identified. Few developmental studies of the cottonseed have been conducted; the precise timing of the synthesis of constituents, sensitive steps in their development, and localization in the seed of many key constituents are not known. Detailed knowledge of seed development is needed to aid in interpreting responses to environmental simuli and to provide insights into modes of genetic and physiological modification to control composition of these storage organs during maturation.

Planting date, irrigation, and time of harvest, etc., determine the cultural environment that interact with climatic factors in determining seed quality. In maturing seeds, these factors can modify metabolic pathways and physiological processes affecting characteristics of cottonseed. Traditional practices, modified production systems, and new innovative production practices should be investigated as to their effect on seed quality. Glandless cottonseed varieties are available, but the exact methods required to produce and deliver gossypol-free cottonseed products have not been defined. Production systems involving glandless need to be evaluated to identify sources of contamination.

4. Objective: Identify the genetic variability of cottonseed composition, determine the genetic control of cottonseed traits, and develop preferred cottonseed quality germplasm; develop an understanding of developmental processes of the plant that leads to improved cottonseed composition, and develop methods to measure and evaluate quality parameters; and identify cultural practices, production systems, and handling procedures suited for the production of high quality seeds.

5. Research Approaches:

   a. Develop accurate macro- and micro-quantitative analytical methods and semi-quantitative evaluation methods for critical quality parameters (e.g., gossypol, cyclopropene fatty acids, protein, oil) of cottonseeds. Priority 1.

   b. Evaluate genetic material, including germplasm collections, for specific seed qualities. Priority 2.

   c. Determine genetic control of specific seed components and seed quality parameters. Priority 4.

   d. Develop germplasm lines with special quality traits in agronomically acceptable backgrounds. Priority 5.

e. Identify production and handling practices necessary to produce commercially acceptable glandless seed. Priority 12.

f. Identify cultural practices that modify metabolic pathways and physiological processes affecting quality characteristics of cottonseed (i.e., physical parameters, seed quality, reduced seed deterioration, and reduced mycotoxin contamination). Priority 16.

g. Investigate production systems other than the traditional to determine capabilities for producing preferred qualities. Priority 20.

h. Determine the localization of seed constituents, particularly proteins, carbohydrates, and cyclopropene fatty acids, in mature cottonseed, and the mobilization of these constituents at the time of germination. Priority 21.

i. Determine key enzymes in seed development, stages of development at which they are active, environmental conditions influencing them, and their effect on seed quality and seedling vigor. Priority 22.

j. Investigate carbon (photosynthate) quantity and distribution in the plant, the effect of environmental factors, identify controls, and devise procedures to channel carbon into desired boll products. Priority 26.

k. Investigate nitrogen metabolism and distribution within the plant, the effect of environmental factors, identify controls, and devise procedures to modify the quantity and quality. Priority 34.

l. Determine the relation between seed composition, stand establishment, and plant performance. Priority 35.

m. Determine effects of locations and environments on the composition and physical properties important to end use of cottonseeds. Priority 36.

n. Obtain valid estimates of quality parameters through performance testing of experimental strains and commercial varieties under standard conditions within climate regions, and beltwide. Priority 37.

o. Utilize systems analysis approaches (computer modeling) to describe the effects of growth and development of the cotton plant on seed quality. Priority 42.

B. Preservation of Inherent Seed Quality

1. SY Situation

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	0.1	1.1	1.2	208
	0.6	0.0	0.6	308
	0.1	1.1	1.2	405*
	2.4	0.0	2.4	406**
	0.1	0.0	0.1	408
	2.6	0.0	2.6	702
No Increase	0.2	0.7	0.9	208
	0.6	0.0	0.6	308
	0.6	1.0	1.6	405*
	2.4	0.0	2.4	406**
	0.2	0.0	0.2	408
	2.7	0.0	2.7	702
20% Increase	0.2	0.7	0.9	208
	0.6	0.0	0.6	308
	0.6	1.0	1.6	405*
	2.4	0.0	2.4	406**
	0.2	0.0	0.2	408
	2.7	0.0	2.7	702
Recommended	0.2	0.8	1.0	208
	0.7	0.0	0.7	308
	0.7	1.2	1.9	405*
	2.9	0.0	2.9	406**
	0.2	0.0	0.2	408
	3.2	0.0	3.2	702

*RPA 307, 405, and 501 combined in 405.

**Redirected research in this RPA contains elements of RPA 408 and perhaps 702.

2. Priority: 2

3. Situation: As a result of environmental, cultural, storage, and processing conditions, seed cotton and cottonseed can be contaminated with materials of toxic, anti-nutritional or disease-producing nature that prevent their use in food and feed products. A need exists for knowledge of potential contaminants of cottonseed products, especially methods for their identification, prevention, and/or elimination. Operations must be designed to include microbial-kill steps in cottonseed processing, and to prevent re-contamination. Physical and chemical methods used to obtain these low microbial levels must not produce carcinogenic or toxic derivatives, or effect the physical, functional and nutritional properties of

cottonseed products. A process for cattle feed has been developed to inactivate aflatoxin in cottonseed meal by treatment with ammonia. An acceptable process needs to be developed for continuous detoxification or aflatoxin in cottonseed and cottonseed meal. Of additional interest are the many other potential mycotoxins that may exist in feed and foods contaminated with microorganisms. Research is needed to identify microorganisms associated with cottonseed, determine conditions for their occurrence, and develop methods to detect biologically active mycotoxins including secondary metabolites. Successful research on improved methods for the rapid detection of mycotoxin, rapid determination of their concentrations, and their elimination from cottonseed and cottonseed products, would lead to the development of preventive techniques to safeguard food and feed from contamination.

The increased pressures for energy conservation, regulatory restrictions, and overall efficiency of operation have accelerated efforts to develop new methods for the harvesting, handling, storing, and processing of seed cotton and cottonseed. The new methods, in some cases, may be detrimental or potentially detrimental, to seed quality. The widespread use of field storage of seed cotton has created a new environmental condition that is potentially detrimental to seed quality. Often the new and more efficient methods of harvesting, cleaning, ginning, and especially those for controlling dust, relate to the speed with which seed cotton and cottonseed are handled, and these changes provide conditions for seed damage and resultant loss in quality. The extent to which changes in physical and chemical properties of cottonseed due to handling and processing can be tolerated without altering economically important end-use processing and product quality should be determined.

At present, the precise physical and chemical components of the cottonseed that contribute to planting seed quality are not known. Research is needed to identify those components that result in the preservation of high quality. Standard germination tests of planting seed fail to accurately predict field performance of planting seed and subsequent plant performance. Thus far, components identifiable with desirable planting seed quality have the same desirable effect of preserving quality for processing.

4. Objective: Develop technology to detect and minimize, eliminate or inactivate microbiological and environmental contaminants in food and feed products of cottonseed; develop new methods and determine the effect of changes in the harvesting, handling, storing, and processing of seed cotton and storage of cottonseed; and identify factors contributing to planting seed quality as it relates to seedling performance, and develop methods to identify viable seeds and materials that will maintain and/or improve planting seed quality.

5. Research Approaches:

   a. Develop continuous detoxification process suitable for commercial application to inactivate mycotoxins or remove them from cottonseed and cottonseed meal. Priority 3.

   b. Determine physiological, biochemical, and anatomical characteristics of the seed that increase the resistance of seeds to deterioration and pathogen attack. Priority 6.

   c. Develop accurate and rapid techniques to detect and quantify mycotoxins in cottonseed. Priority 8.

   d. Develop tests, supplementary to the standard germination tests, for determining viability and vigor of planting seeds. Priority 9.

   e. Determine the potential problem and possible remedial methods for problems in field storage. Priority 10.

   f. Determine the effect of changes in existing harvesting, cleaning, and ginning equipment on cottonseed quality, and develop new methods, treatments, and machinery, especially those for controlling dust during handling of cottonseed to insure that the inherent seed quality is maintained. Priority 15.

   g. Characterize compositional changes in cottonseed that occur during various storage conditions, determine methods of controlling them, and examine extent of change that can be tolerated without altering end-use processing and product quality. Priority 19.

   h. Identify microorganisms on cottonseed, determine conditions for their occurrence, and synthesis of mycotoxins, including precursors and secondary metabolites, isolate these constituents, and assess their biological activity. Priority 23.

   i. Identify conditions (environmental, genetic, and chemical) that reduce sporulation and growth of microorganisms during preharvest, harvest, and postharvest, including processing, handling and storage operations. Priority 24.

   j. Determine impact of quality planting seed on plant performance. Priority 38.

   k. Determine the effect of harvest-aid chemicals on cottonseed quality and develop improved methods of application. Priority 40.

   l. Determine if preharvest applications of fungicides reduces seed deterioration and improves germination and field emergence. Priority 43.

C. Processing and Utilization of Cottonseed

1. SY Situation

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	6.4	1.7	8.1	406
No Increase	6.4	1.6	8.0	406
20% Increase	6.4	1.6	8.0	406
Recommended	7.7	1.9	9.6	406

2. Priority: 3

3. Situation: Glandless cotton cultivars and the liquid cyclone process lowered gossypol content in cottonseed and cottonseed flour respectively, and improved the potential of these products as protein ingredients in food. Economics and research directions of cotton are controlled by fiber yield and quality whereas seed quantity and quality have secondary considerations. Development of the technology for producing food-grade protein from cottonseed has increased the incentive to coordinate research to improve processing and utilization of cottonseed with efforts to maintain optimum cotton fiber properties. There is no doubt that cottonseed has excellent potential to become a source of edible vegetable protein. However, the same is true for other vegetable-protein sources, especially soybeans, peanuts, and sunflowers. Great advances have been made with soybean products which are now commercially available as ingredients in many foods. Thus, strong competition in the food market exists and development of cottonseed products as food ingredients depends upon efforts to characterize, modify, interrelate, and utilize their unique physio-chemical, functional and nutritional properties. These efforts should include determination of processing variables that effect end-use quality of the cottonseed products. Increased economic and regulatory constraints require the development of new processing methods that conserve energy and water and eliminate or reduce pollution. Research should also include the detection, identification, and removal of nonnutritive substances, the characterization of materials causing flavor deterioration, and determination of ways to utilize by-products of food processing in animal feeds.

4. Objective: Associate physio-chemical composition of cottonseed and their products with new and unique food functional and nutritional properties; detect, identify and remove nonnutritious substances in cottonseed products; determine processing variables affecting end-use or product quality; develop energy efficient food processes; and utilize by-products of cottonseed processing in animal feeds.

5. <u>Research Approaches</u>:

   a. Determine in cottonseeds and their products the identity and content of nonnutritive, or undesirable components and develop methods to remove those that adversely affect quality. Priority 7.

   b. Characterize physical and chemical properties of cottonseed protein products and identify those constituents that contribute to unique functional and nutritional properties in food. Priority 11.

   c. Determine nutritive value, with humans, of cottonseeds and their protein products in food systems. Priority 13.

   d. Develop new energy efficient and economical procedures for converting cottonseed into component products. Priority 14.

   e. Develop new procedures for corefining different oils with cottonseed oil, to eliminate hydrogenation, and producing products with desirable functional and nutritional properties. Priority 17.

   f. Modify chemically the protein properties of cottonseed products to develop new functional properties for expanded food use. Priority 18.

   g. Develop new and improved methods to identify and quantity changes during processing of constituents of cottonseed that are critical to product quality. Priority 25.

   h. Develop new, energy efficient, nonpolluting processes for oil refining and processing. Priority 27.

   i. Establish the extent to which processing variables affect the end-use quality of edible cottonseed. Priority 28.

   j. Identify volatile compounds in raw and processed cottonseed products that contribute to flavor, and develop mathematical models for correlating instrumental and sensory data. Priority 29.

   k. Develop methods for dehulling glandless cottonseed and production of kernels, roasted nuts, solvent-extracted flour, and protein concentrates and isolates for food use. Priority 30.

   l. Develop new energy and water efficient nonpolluting processes for producing protein concentrates and isolates from cottonseeds for food use. Priority 31.

   m. Develop techniques for stabilizing quality of delinted and dehulled <u>glandless</u> cottonseed during storage and transport, <u>especially during export</u>. Priority 32.

n. Determine nutritive value of cottonseed by-products in animal feed systems. Priority 33.

o. Develop and evaluate new food products containing cottonseed protein derivatives that provide improved functional and nutritional properties. Priority 39.

p. Determine fatty acid composition and triglyceride rearrangement of oil for development of products with unique physical properties, nutrition, and performance value. Priority 41.

RESEARCH OPPORTUNITIES

COTTON MARKETING AND ECONOMIC ANALYSIS

(Includes Portions of Research in Research Problem

Areas 309, 503, 506, 507, 508, 509, 601, and 808)

SITUATION

The declining competitive strength of the cotton industry is a matter of continuing concern to industry members and public policy makers. The cotton industry will continue to face many complex economic adjustments arising from changes in market conditions, Government policies and programs, technology, and exogenous shocks. The impact of these factors, coupled with stiff competition from man-made fibers and foreign-grown cotton, has been felt by all segments of the cotton industry from producer to manufacturer. International trade in cotton and textiles further complicates the assessment of the economic viability of the American cotton industry and is extremely important as a national policy issue.

Considerable research has been devoted to identifying, describing and quantifying the cotton industry structure and practices. The input and cost structure from the farm to the mill door has been well documented. This information should be improved and kept current for analytical use. Especially needed is an improved data base for evaluation of those factors affecting export demands for U.S. cotton, as the viability of the U.S. cotton industry depends heavily on exports of raw cotton.

A system of models, techniques, and analytical procedures should be applied to organize and interface this information to make possible integrated analyses and evaluation of production, marketing, utilization and trade problems and policies for the cotton industry. Such a system of models would provide estimates of the impact of changes in such factors as Government policy, technology or other variables on individual farms and regions and on the structure and performance of the cotton industry and related sectors.

Reliable forecasts of supply, demand and prices of cotton and cottonseed are essential to efficient and orderly marketing and to the improvement of cotton's competitive position. Greater emphasis on evaluation of the international fiber and textile trade is needed in view of the heavier reliance on world markets. Interdependency between U.S. and foreign economies must be thoroughly modeled to improve forecasts of U.S. cotton production, use, and price.

Both public and private decision makers would benefit from the results of such a coordinated research program: (1) farmers, through the development of improved cultural practices reducing the cost of producing cotton, optimizing farm product mix and improved outlook information; (2) ginners, warehousemen and other middlemen, through the development of improved practices and the evaluation of potential effects of farm and industry adjustments on performance; (3) the textile manufacturing industry, through the development of information on supply projections and the demand for various qualities of cotton and competing fibers and potential tradeoffs of price, processing performance and end-use; (4) consumers, through a higher performing producer-consumer fiber complex; and (5) national policy makers, by having more complete and current intelligence on the total system and the economic relationships within it to assist in evaluating the impact of alternative policies and programs on various factors including production adjustments, income support, price stability, depreciation allowances, environmental quality, and international trade.

Fulfillment of the various objectives that are grouped in this report by Research Problem Areas often requires data and information listed under other Research Problem Areas. If funding were to be cut in one or more areas, care should be taken to maintain the data and information needed for analysis in each subsection of the cotton system.

The following proposed program in marketing and economic research reflects the judgment of many researchers. The subtopics and report writers were as follows:

(1) RPA 800. Government Policy.
R. Samual Evans, ESCS, Washington, D.C.

(2) RPA 601. Foreign Marketing.
George E. Deariso, FAS, Washington, D.C.

(3) RPA 506. Supply, Demand and Price
R. Samuel Evans, ESCS, Washington, D.C.

(4) RPA 503. Marketing Efficiency.
Joseph L. Ghetti, ESCS, Stoneville, Ms.

(5) RPA 309. Production Systems.
Irving R. Starbird, ESCS, Washington, D.C.

(6) RPA 509. Marketing Systems.
Joseph L. Ghetti, ESCS, Stoneville, Ms.

(7) RPA 507. Competitive Interrelationships.
R. Samuel Evans, ESCS, Washington, D.C.

(8) RPA 508. Product Development.
Ray S. Corkern, ESCS, New Orleans, La.

SPECIFIC RESEARCH ACTIVITIES

A. Government Programs and Policies Affecting Cotton

1. SY Situation:

Support level	Number of SY's ESCS[1/]	SAES	Total	RPA Distribution
Current	1.4	0.0	1.4	808
No Increase	2.0	1.0	3.0	808
20% Increase	2.0	1.5	3.5	808
Recommended	2.5	1.5	4.0	808

2. Priority: 1

3. Situation: There is a continuing need for economic analyses and information to guide policy decisions. There is a need to identify and evaluate the immediate impacts of Government program alternatives (including no program) on such factors as the acreage and production of cotton and other crops, location of production, cotton prices, farm income, and program expenditures. Major questions also center around the longer-term effects of program and policy changes, changes in domestic and export market conditions, technology, and exchange rates on the competitive position of U.S. cotton.

   Policy questions are often concerned with the immediate or short-run (1 or 2 years) impact of Government program alternatives. Answers to such questions require information on the short-term effects of program changes on a variety of factors including production, resource use, prices, farm income, and Government expenditures.

   Other policy questions relate to a longer-term (5 to 10 years) adjustment process. Research in this area centers on the long-run impacts of changes in market conditions, technology, and Government policy. Information relating to all three problem areas is essential for the formulation of effective policies and programs affecting the cotton sector.

4. Objectives: To evaluate the short-run response of cotton producers to changes in Government program variables; to identify and appraise the longer-term impacts of factors affecting aggregate supply response and adjustments in resource use under alternative Government policies.

1/ Economics, Statistics, and Cooperative Service, U.S.D.A.

5. Research Approaches:

a. Examine the short-run and long-run consequences of alternative program provisions on price, carryover, and utilization of cotton.

b. Estimate the immediate production response of cotton to changes in program provisions--including target prices, loan rates, and set-aside or diversion payments--and the impact of these changes on cotton prices and the level of Government expenditures on cotton programs.

c. Identify and evaluate the short-term and long-term regional impacts of program changes on cotton production, resource use, farm income, cotton processing and supporting sectors, and local economies, including the comparative advantage of different regions or areas in the production of cotton, which arise from specific program changes and a free market situation.

d. Identify, evaluate, and project changes in the structure of cotton farms (number and size of producing units, and distribution of resources), and the cotton supporting subsectors.

e. Estimate the longer-term aggregate response of firms in the cotton subsector to changes in program variables including the phasing out of program payments and operating under free market conditions.

f. Assess adjustments in longer-term equilibrium conditions arising from changes in domestic and export demand, major changes in technology, and important changes in Government policies affecting cotton and competing crops.

B. Foreign Market Development

1. SY and Situation:

Support level	Number of SY's ESCS	SAES	Total	RPA distribution
Current	0.0	0.3	0.3	601
No Increase	1.5	0.0	1.5	601
20% Increase	2.0	0.5	2.5	601
Recommended	3.0	0.5	3.5	601

2. Priority: 2

3. Situation: Those concerned with the export of U.S. cotton can do a more effective job of marketing if they have up-to-date information on the fiber properties of the cottons with which U.S. cotton must compete. This calls for continuing studies to determine the fiber properties of foreign cottons and to evaluate their competitive strengths and weaknesses compared to domestic cottons. A comparative analysis of neps in foreign cottons and U.S. growths used or intended for use in the production of similar yarn and fabric would answer many questions which are currently being answered in a very speculative manner.

   Published price series which are now considered as indicative of world cotton prices leave much to be desired with respect to their representation of American growths. The series most frequently cited is a C.I.F. Northern European Quotation (Liverpool). In contrast, most of the cotton exported by the U.S. goes to Southeast Asian mills. Also, since the C.I.F. Northern European price is not compiled by a public agency such as FAS or AMS, the U.S. Government cannot verify its accuracy. Thus, there appears to be a need for a representative (for the U.S.) C.I.F. world index price for cotton.

   There have been prolonged periods when cottons produced in particular countries have appeared to be experiencing growing popularity in the aggregate or in particular markets while other countries' cotton exports were declining in popularity. The U.S. cotton industry needs to know what accounts for shifts in market shares and what can be done on behalf of U.S. cotton to improve its popularity. There is need to develop an understanding of: (1) the factors that determine the well-being of the textile industries within nations that comprise our raw cotton export markets; (2) the basis used by firms in deciding what raw materials to buy; and (3) which sources they turn to for their cotton and/or man-made fiber.

   Foreign cotton production has made rapid strides and now accounts for about 80 percent of the cotton moving in international trade. Planning for U.S. cotton markets, therefore, must take into account prospective changes in foreign cotton production. This calls for detailed knowledge of the cotton economy of the countries involved.

4. Objectives:

   a. Ascertain the fiber characteristics of foreign cottons relative to U.S. growths and determine the nep count associated with each.

   b. Collect the necessary data and develop a representative C.I.F. world index price for cotton in Southeast Asia.

   c. Identify business practices, economic and political factors that are associated with improving or determining

the market share prospects for particular U.S. and foreign cottons, especially in important hard currency areas.

d. Compile a detailed data base on the factors influencing cotton production in foreign countries and use this base to anticipate and evaluate the impact of such changes upon the export market for U.S. cotton.

5. Research Approaches:

a. Obtain samples of major qualities from each important foreign cotton producing area and subject these samples to fiber and spinning tests. The resulting data will then be evaluated to determine any changes which are occurring in the quality of foreign cotton production and to compare them to commercially equivalent U.S. cottons. All samples will also be subjected to card web nep tests.

b. Collect price data from foreign cotton users and develop a C.I.F. world index price for cotton. U.S. cotton prices will then be compared to competing foreign growths.

c. Identify recent periods and foreign markets in which rapid market share changes have occurred and ascertain the business practices, economic conditions and political environments which cause the shifts. Using the information compiled, develop recommendations as to how the market position of particular U.S. cottons can be safeguarded and improved.

d. Foreign cotton production can be researched with: (1) qualitative analysis, where the researcher develops a sufficient grasp of the cause and effect relationships in the agriculture of present and potential cotton growing areas to be able to anticipate the impacts of changes on cotton acreage, yield, and production; and (2) quantitative analysis, whereby the researcher attempts by statistical analysis to measure the response to changes and develop a reliable basis for projecting acreage, production, exports and prices of cotton.

C. Cotton Supply, Demand, and Price Analysis

1. SY Situation:

Support level	Number of SY's ESCS	SAES	Total	RPA distribution
Current	7.8	0.3	8.1	506
No Increase	7.5	0.4	7.9	506
20% Increase	7.5	1.0	8.5	506
Recommended	7.5	1.0	8.5	506

2. Priority: 3

3. Situation: Data series and analytical methods need to be constantly improved. Individual producers, processors and marketing firms, including exporters and end-users base daily decisions upon information concerning probable future supply, demand, and price conditions. Sound public policy decisions and cotton legislation are dependent upon such information. Farm supply industries also need reliable forecasts so they can make necessary adjustments to prospective changes in the demand for their products.

   With more reliance on world markets and less government involvement in cotton support, the problem of quantifying economic factors affecting the supply and demand for cotton and cottonseed becomes more critical. Both farmers and textile interests need improved analyses of the supply and demand for cotton on which to base their plans. Thus, public economic research must provide continuous appraisal of the current and prospective economic position of cotton and cottonseed to cotton producers and for a large segment of the supporting industries.

4. Objectives: Develop reliable forecasts of supply, demand, and prices of cotton and cottonseed to promote efficient and orderly marketing of cotton and to enhance cotton's competitive position.

5. Research Approaches:

   a. Develop and improve data series on supply, demand, and prices for cotton, cottonseed, man-made fibers, and textiles.

   b. Apply statistical and econometric techniques that better identify and measure factors affecting domestic and foreign cottonseed supply and demand.

   c. Analyze the effects of changes in domestic and foreign cotton supplies on prices of raw cotton textiles.

   d. Evaluate the international fiber and textile situation and its effect on U.S. cotton and textile trade.

   e. Examine factors affecting consumption in various cotton end-uses and estimate raw cotton quality requirements for domestic use and export.

   f. Analyze interfiber competition and interoilseed competition and provide timely information on competitive market conditions.

D. Efficiency in Marketing Cotton

1. SY Situation:

Support level	Number of SY's ESCS	SAES	Total	RPA distribution
Current	1.9	2.5	4.4	503
No Increase	2.0	3.0	5.0	503
20% Increase	2.0	3.3	5.3	503
Recommended	2.0	4.0	6.0	503

2. Priority: 4

3. Situation: A large percentage of the retail value of cotton and cottonseed is accounted for by the farm supply, processing, and marketing sectors. The cost of supplying production inputs and providing consumers with cotton and cottonseed products is directly affected by the type of facilities, equipment and methods used. Research designed to identify and develop ways to eliminate outdated and inefficient facilities, equipment, and methods employed can greatly reduce these costs. Moreover, as consumers demand more marketing services and inflation continues to rise, efficiency in marketing will become even more important.

The present cotton ginning, handling, and merchandising system for cotton and other fibers is one of the least efficient steps in marketing of U.S. fibers. Over capacity of ginning facilities, inefficiently designed and antiquated storage facilities greatly increase fiber handling, storage, and merchandising cost.

Research designed to estimate ginning and handling cost will aid ginners, warehousemen, and others in evaluating the impact of reducing costs through adoption of technologies that increase efficiencies in various steps in the overall marketing system.

The current classification system is a labor intensive system that depends highly on the experience and skills of classifiers. The National Cotton Marketing Study Committee has recommended that the Department expand its effort to develop an instrument system of classification so that consistent results will be insured. In response, the USDA is conducting a field-test of instrument classification.

4. Objectives:

   a. Provide information which will assist in reducing costs and increasing the efficiency of firms and functions involved with moving cotton and cotton products from farm to manufacturers.

   b. Determine if instrument classification is workable in USDA Cotton Classing offices and evaluate the impact of adoption of instrument quality information on the cotton marketing system.

5. Research Approaches:

   a. Employ surveys and economic-engineering techniques to determine and maintain data on current costs and charges for processing, handling, storing, and merchandising cotton and other fibers.

   b. Analyze influence of variation in volume, capacity utilized, location, type of facility, new technology, and related factors on cost.

   c. Determine optimum size, number, location, and configuration of processing and storage facilities needed to satisfy specific domestic and foreign demand under alternative conditions and policies.

   d. Quantify marketing margins and cost components at each stage in the marketing-processing-distribution system and project these margins and costs to future seasons.

   e. Evaluate effects of government programs and policy changes on the structure, efficiency, and viability of natural fibers processing-distribution sectors.

   f. Conduct surveys of various marketing segments (growers, ginners, merchants and mills) to determine the effects of new quality information provided by instrument classification.

   g. Apply econometric methods to estimate price impacts of instrument-classified cotton, using data collected from grower sales to merchants.

E. Production Systems for Cotton

1. SY Situation:

Support level	Number of SY's: ESCS	SAES	Total	RPA distribution
Current	2.4	2.4	4.8	309
No Increase	1.5	2.5	4.0	309
20% Increase	1.5	3.5	5.0	309
Recommended	2.0	4.0	6.0	309

2. Priority: 5

3. Situation: The production of cotton contributes importantly to the protection, nutrition and pleasure of people worldwide. It constitutes an important part of the economy of several Southern States. In 1977, the farm value of cotton lint and seed produced totaled about $4 billion. Cotton exports contribute significantly to our balance of payments as roughly 45 percent of the cotton crop is exported annually.

   Economies in producing and marketing cotton must be achieved if U.S. cotton is to compete favorably with man-made fibers and with cotton produced abroad. Cotton production and marketing costs are increasing at an excessive rate, especially in view of the heightened competition from man-made fibers. Research on production systems should make it possible to reduce production costs through more efficient use of resources. The increasing complexities of production systems and subsystems often require the participation of interdisciplinary teams in research. Research on production systems requires a combination of research talents to be most effective. Existing or new production techniques must be appraised in terms of their interrelationships with other practices in the production system. Often a practice or machine that appears promising has shortcomings when fitted into the total farm system.

4. Objectives:

   a. Determine resource requirements for alternative ways to produce cotton and major competing crops and develop procedures to determine optimum organization and input strategies for farms producing cotton.

   b. Specify and evaluate complete or partial systems of cotton production practices which will significantly reduce production costs and maintain or improve returns to the cotton enterprise.

5. Research Approaches:

   a. Develop and maintain a current set of enterprise budgets and programming models as a data base for economic analysis of alternative crop and livestock production systems. Determine land, labor and capital requirements for various combinations of production practices and technologies used to produce cotton. Document the input and cost structure from the farm to consumer.

   b. Determine economic impact of alternative pest management strategies in producing cotton, including eradication, current Extension programs and other alternative insect control approaches.

   c. Evaluate production systems that require less fossil fuel and conserve energy without reducing productivity.

   d. Determine resource requirements for producing cotton with alternative irrigation systems, determine costs and returns for each alternative system, analyze the economic feasibility of investments in irrigation systems, and determine the aggregate economic impacts.

   e. Modify and refine existing water management decision-making models for application to cotton. Evaluate the longer-term economics of water management through the use of crop growth simulation models.

   f. Determine cost and return impacts of short-season production systems.

   g. Evaluate production costs and returns for alternative methods of land preparation, tillage and harvesting. Use a team concept in developing and evaluating new systems for producing crops at a lower cost.

   h. Use computer programs to determine harvesting and seed cotton handling systems that would maximize returns for typical farms and gin communities.

F. Performance of Marketing Systems

1. SY Situation:

Support level	Number of SY's			RPA distribution
	ESCS	SAES	Total	
Current	4.7	0.3	5.0	509
No Increase	3.0	0.0	3.0	509
20% Increase	2.5	0.5	3.0	509
Recommended	2.5	0.5	3.0	509

2. Priority: 6

3. Situation: Performance is a measure of the costs and benefits flowing from a given or alternative type of market organization. A traditional measure has been that of farm-to-retail price spreads over time. Although changing spreads may signal needs for adjustment in the market structure, small spreads are not necessarily an indication of efficiency. Some of the marketing needs now confronting cotton will add to marketing costs but will simultaneously, or shortly thereafter, add a greater value to the final consumer products and to producer income.

   It is essential to concentrate effort on market performance of the existing marketing structure to achieve the best possible competitive position for cotton. However, in the longer-run, end goals must be examined and an efficient marketing system structured for effective achievement.

   The cotton industry must comply with OSHA dust control (air quality) standards, which were implemented in 1978 and which require full compliance by 1981. The standards, applicable to textile mills, warehouses, and cottonseed oil mills, may cause severe economic adjustments in U.S. cotton/textile industries.

4. Objectives:

   a. Estimate the economic impacts of air quality standards on cotton industry and on the U.S. economy and assess the potential for selected new technologies to alter those impacts.

   b. Given that the relationship between income stability and profit maximization is complementary only within a given range, develop the combination of marketing options which will minimize income variability at alternative levels of profit maximization.

   c. Determine the critical marketing functions a cotton marketing system must provide or improve if cotton is to be competitive in the total fiber market, and ascertain the effective marketing organization alternatives that would enable achievement of the critical marketing functions for cotton.

5. Research Approaches:

   a. Use econometric and simulation models to measure economic impacts of OSHA dust standards, with emphasis on structure of the U.S. fiber industry, employment, farm income, and foreign trade in cotton and textiles.

   b. Utilize nonlinear programming to determine that combination of marketing options which maximizes income under specified

levels of risk acceptance. These models would have to be developed for each of the major producing regions to account for locational yield variability.

c. Conduct an in-depth analysis of the fiber market decision-making process to identify those factors which have a critical influence upon the selection of fibers. Conduct in-depth studies among selected and key firms in various types of fiber product marketing.

G. Competitive Interrelationships in the Cotton Sector

1. SY Situation:

Support level	Number of SY's			RPA distribution
	ESCS	SAES	Total	
Current	0.0	0.4	0.4	507
No Increase	0.0	0.0	0.0	507
20% Increase	0.5	0.0	0.5	507
Recommended	1.0	0.0	1.0	507

2. Priority: 7

3. Situation: Considerable research has been devoted to a description of the entire cotton industry including land resources, labor, capital, location and capacities of marketing facilities in the cotton producing regions of the United States. Econometric models of the cotton producing and consuming sectors have been developed. These, however, are used primarily to predict or explain changes in raw cotton supply, use, and price in an aggregative sense. An input-output model of the cotton industry and supporting sectors is also available, but it is used in isolation of the econometric models. This work provides the basic inputs required to develop a cotton systems model for use in measuring the impact of adjustments in one segment of the cotton industry on the entire industry and supporting sectors.

   Changes in Government policies and/or regulations, in technology and in yields, production costs and prices of cotton and competing crops will impact on cotton's competitive position within and among producing regions, and with man-made fibers. Also affected will be processing and marketing facilities and firms supplying inputs to the cotton sector.

4. Objectives: Determine the regional and total economic impacts (income, employment) of changes in cotton production, use and exports, and in cotton textile trade.

5. Research Approaches: Existing models could be used to measure the impacts of economic, technological, or policy changes on regional cotton production and the total economic impact. The econometric models could also be used to measure impacts on raw cotton production, use, exports, and price. These effects could then be inputs to an input-output model to determine impacts on cotton processing sectors, supporting sectors, and on regional economies and the national economy.

H. Product Development

1. SY Situation:

Support level	Number of SY's ESCS	SAES	Total	RPA distribution
Current	0.0	0.0	0.0	508
No Increase	0.0	0.0	0.0	508
20% Increase	1.0	0.0	1.0	508
Recommended	1.0	0.0	1.0	508

2. Priority: 8

3. Situation: The development and introduction of new cotton textile products is still a viable means of expanding and maintaining markets for cotton fabrics, household and industrial products. Recent technical progress relating to yarn fabrication, nonwovens recycling, cold plasma, nonaqueous solvent dyeing, and chemical modifications provide new avenues for further improvement in cotton textile products.

   About 50 percent of domestic cotton is used for apparel products. New textile products are being introduced into this competitive market. If cotton apparel products are to remain competitive, they must equal or surpass other apparel products in aesthetic as well as technical and functional characteristics. Some innovative processes have been developed on a laboratory scale which could impart desirable and appealing characteristics to cotton fabrics.

   It should be noted that in determining the resources to be allocated to RPA 508, strong consideration was given to the resources at the disposal of Cotton Incorporated. It was felt that Cotton Incorporated is better suited to conduct this type of research and speed adoption of the results. However, this does not imply that public scientists should not be supported in product development work--especially research of a basic nature.

4. Objectives: Market-test new cotton textile products that are fabricated, chemically modified, and dyed by various combinations of the processes which have been developed and tested on a laboratory scale.

5. Research Approaches:

    a. Test and evaluate consumer reactions to new cotton textile products.

    b. Evaluate the time lag and factors that influence consumer acceptance of apparels fabricated by new laboratory processes.

RESEARCH OPPORTUNITIES
RESOURCE CONSERVATION

(Includes Portions of Research in Research Problem Areas

102, 103, 105, 106, 207, 208, 209, 307, 308, 309, 407 and 709)

SITUATION

The energy crisis has brought into sharp focus the urgency of greater dedication of our people to the conservation of resources. There are many research opportunities to apply resource conservation measures to cotton production and processing, while not neglecting the essential aspects of profit for each part of the cotton industry. These opportunities can be grouped into the general areas of energy conservation, soil and water conservation, and chemical conservation.

National concern with the conservation of energy resources adds a new priority to engineering machinery and process design for optimizing cotton production, harvesting, ginning, and utilization. There are established bases for developing new tillage and cultural practices that conserve fuel and chemical energy. Application of engineering and management techniques can reduce processing energy. Techniques to maintain food and fiber production under conditions of curtailed energy supply and high energy costs need to be developed.

The extensive use of chemicals in cotton production and processing has been a major factor in improving its high production efficiency. It is important that these chemicals be managed appropriately. About 80 percent of pesticides are applied as liquids or sprays. Some studies have shown that as much as 75 percent of the sprays do not reach the target due to evaporation, drift, and other factors. Efficient production requires addition of plant nutrients which are often applied at rates above the current crop need. Most nutrients are water soluble and can be lost through soil and water losses. In many cases, those lost chemicals and nutrients become pollutants to our soil, water, and air. The concern for improvement in the quality of our environment with attendant need to meet regulations, and the increasing costs associated with the chemicals used in cotton production have focused attention upon the need for chemical conservation.

Few will dispute the statement that soil and water are our most important natural resources. Yet these resources are often taken for granted in long-term planning for research to preserve the cotton industry. Most researchers and cotton producers have long recognized these important natural resources but have left it up to the "soil and water researchers" to take care of this aspect while we concentrated primarily on efficiency of production and profit. Profit

cannot be ignored but the importance of soil and water conservation also cannot be ignored. The Clean Water Act (PL 500, Sec. 208) has brought the importance of soil and water control to our attention. New systems that reduce runoff and erosion in cotton production must be employed. Water-use efficiency must be improved. If technology for these ends, such as optimum tillage, cover cropping, multiple cropping, rotations, no-till, traffic control, etc., is not sufficiently developed to meet the needs, we should be addressing our research to these problems.

Simulation modeling is mentioned by several of the subcommittees. This subcommittee feels that although we have not given top priority to simulation modeling per se, the technique should be supported and funded so that it can be applied as a research tool to improve research planning and implementation in many of the research areas, including conservation of resources.

Analyses and recommendations are divided into three major subareas--I - Conservation of Energy, II - Conservation of Soil and Water, and III - Conservation of Chemicals.

I - CONSERVATION OF ENERGY FOR COTTON PRODUCTION AND PROCESSING

SPECIFIC RESEARCH ACTIVITIES

A. Production Practices to Reduce Energy Requirements

1. SY Situation:

Support level	Number of SY's			RPA
	SEA-AR	SAES	Total	distribution
Current	0.0	0.1	0.1	307
	2.5	1.4	3.9	308
	0.0	0.8	0.8	309
No Increase	0.0	0.1	0.1	307
	1.4	0.8	2.2	308
	0.0	0.4	0.4	309
20% Increase	0.0	0.2	0.2	307
	1.7	1.0	2.7	308
	0.0	0.4	0.4	309
Recommended	0.0	0.2	0.2	307
	3.0	1.4	4.4	308
	0.0	1.0	1.0	309

2. Priority: 3

3. Situation: Unless substantial increases in SY's are made research relating to energy and production is fast losing ground. Engineering technology offers one of the few solutions to the problem of reducing energy requirements for cotton production.

4. Objective: To develop engineering methods for cotton production to reduce energy requirements and optimize plant growth, production, and lint and seed quality.

5. Research Approaches (in order of priority):

   a. Develop optimum number and kind of machine operations to reduce power and labor requirements through cultural practices such as minimum tillage, traffic control, and multiple cropping.

   b. Develop methods of effective pest control with less technical material.

c. Develop cultural practices and determine the most suitable varieties to reduce the length of the growing season to minimize cultural and pest control energy.

d. Develop ground methods to rapidly apply pesticides for control of weeds.

e. Develop tools with monitoring and feedback control that apply materials or act upon the soil and plant with minimum energy rate to accomplish specific goals.

f. Develop models of cotton production systems by developing and interfacing submodels of soil moisture, seedling emergence, plant growth, nutrient, insects, weeds, and diseases.

B. Harvesting Technology to Reduce Energy Input and Environmental Problems Created by Cotton Dust

1. SY Situation:

	Number of SY's			RPA
Support level	SEA-AR	SAES	Total	distribution
Current	0.6	0.6	1.2	308
No Increase	0.4	0.4	0.8	308
20% Increase	0.7	0.7	1.4	308
Recommended	1.0	0.7	1.7	308

2. Priority: 4

3. Situation: Research relating to energy and harvesting cotton is very limited. Without an increase in funding only about one-half SY will be devoted to this important high-priority research.

   Pressure on the cotton industry to remove dust, foreign matter, and on energy conservation is dictating that Agricultural Research take drastic action. It is likely that the most rapid progress toward solution of these problems can be made by engineering technology.

4. Objective: To reduce the total energy in harvesting including consideration of reducing trash and dust in seed cotton.

5. Research Approaches (in order of priority):

   a. Investigate conveying systems on harvesters to improve stick removal and reduce energy.

   b. Develop more efficient cleaning equipment for harvesters.

c. Investigate alternative harvesting methods to help alleviate environmental problems related to cotton dust.

d. Study the interrelated effects of cultural systems and plant characteristics, harvester designs, and harvesting methods to increase harvesting rate and energy efficiency.

C. Ginning Technology for Energy Conservation

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	0.6	0.0	0.6	308
No Increase	0.6	0.0	0.6	308
20% Increase	0.7	0.0	0.7	308
Recommended	2.0	0.0	2.0	308

2. Priority: 2

3. Situation: Energy consumed in ginning represents a significant proportion of the total energy required to produce a usable textile fiber. Ginning one bale of cotton requires 40 to 90 KWH of electricity and 200,000 to 500,000 BTU of heat for drying. The seed cotton drying and materials-handling operations account for over 70 percent of the energy consumed in the ginning process.

Energy utilization has not been a major factor in the development of ginning systems in the past because of low energy prices. Consequently, today's ginning system involves a large number of processing steps and the extensive use of pneumatic conveying. The cotton fiber is handled 7 to 9 times by conveying systems during the ginning process, and additional systems are required for conveying trash and cottonseed. These handling operations not only consume large amounts of energy, but they also contribute to air pollution problems. Significant energy savings could be realized (1) through improved machinery utilization to reduce the number of processing steps and attendant-handling operations; (2) by developing more energy-efficient materials-handling systems; and (3) by improving the operating efficiency of seed cotton drying and cleaning systems. Consideration should also be given to alternate sources of energy for supplemental use at gins. Recently several promising techniques have been developed for reducing the energy required for seed cotton drying. These techniques should be further refined to permit wide-scale adoption by the ginning industry.

4. Objective: To reduce the energy required in handling cotton throughout the ginning process.

5. Research Approaches (in order of priority):

   a. Investigate alternate sources of energy for drying seed cotton.

   b. Develop low-air-volume drying techniques for seed cotton.

   c. Investigate the feasibility of low temperature, solar-assisted aeration systems for drying seed cotton during gin gard storage.

   d. Develop practical low pressure steam power for cotton ginning operations using gin trash as the primary fuel.

   e. Develop more efficient materials-handling systems for gins to reduce energy and dust.

   f. Investigate the feasibility of mechanically integrating individual seed cotton and lint processing machines to eliminate or reduce inefficient pneumatic conveying systems.

   g. Determine the most energy efficient power delivery systems for single and grouped machines.

   h. Develop energy management guidelines for ginning.

D. Energy Reduction in Processing of Lint and Seed

1. SY Situation:

	Number of SY's			RPA
Support level	SEA-AR	SAES	Total	distribution
Current	0.4	0.0	0.4	407
	0.3	0.0	0.3	709
No Increase	0.2	0.0	0.2	407
	0.1	0.0	0.1	709
20% Increase	0.3	0.0	0.3	407
	0.1	0.0	0.1	709
Recommended	1.0	0.0	1.0	407
	0.1	0.0	0.1	709

2. Priority: 1

3. Situation: It has been estimated that about 1.9 x 10^6 BTU of energy are required to produce 100 lbs. of baled cotton lint. Processing of that line into a textile product requires a further 6 x 10^6 BTU.

Desizing, scouring, bleaching, dyeing, resin treatment, curing, and process washings are estimated to consume between 2.3 and 2.9 x 10^6 BTU per 100 lbs. of cotton processed. Approximately one-fifth of the energy used in finishing is for transportation and handling, the balance for heating water, drying, and curing the fabrics. Depending upon the type of fabric and its end-use, cotton-containing textiles are wet and dried as many as 7 times in their evolution from greige goods to consumer-ready fabric.

The textile industry philosophy over the past 4 to 5 decades has been based upon the assumption that cheap and abundant energy would always be available. As a consequence, the addition of finishing operations to obtain special end-use properties such as durable press, flame retardance, water repellance, and soil release have been haphazard and inefficient. Systems analysis and chemical engineering design for efficiency was almost invariably lacking. Little, if any, effort has been made to reclaim sensible heat from gaseous or liquid effluents.

A major consideration in the utilization of cottonseed is the need to remove the linters, the short fibers that remain on the seed after de-linting. Approximately 2 x 10^8 lbs. of first-cut linters and approximately 4.5 x 10^8 lbs. of second cut linters are produced by oil mills annually. The removal of these fibers from the seed is energy intensive, the requirements amounting to 30-35 percent of the total energy used by oil mills. Yet these linter fibers must be removed if highly nutritious proteins in cottonseed meals or flours that remain after the removal of the oil are to be upgraded to make them acceptable for use in foods for human consumption.

4. Objective: To reduce the total energy required to process cotton lint into fabric and cottonseed into oil and meal while maintaining or improving the quality of the finished product.

5. Research Approaches (in order of priority):

   a. Mechanical, aerodynamic, and electrostatic techniques will be investigated as a means of more efficiently processing cotton from bale to yarn in a continuous system; continued improvement in the operation of a prototype tuft-to-yarn processing system will be sought concurrent with increased opening and cleaning efficiency and an expanded capability of distributing fibers to 20 processing units; methods of supplying a source of electrostatically-charged cotton fibers will be developed to improve the efficiency of the proposed electrostatic processing and spinning system; to conserve energy, individualized fibers will be formed into

sheets by the paper process, electrostatically, or supersonic means and slit into yarns for weaving; alternatively parallelized fibers which will then be bonded, dried, and slit into yarns for weaving without the need for twisting; modify open-end spinning machine parts to improve the efficiency of yarn manufacture concurrent with the production of the strongest yarn of the finest count.

b. Electrostatically attach size to yarns in the absence of water and melt at low temperature; develop reusable hot-melt (100° C) sizing systems; develop filament wrap for cotton core yarns that does not need to be removed from the fabric; develop high-speed coating systems with thixotropic properties, or capable of being polymerized by light, or by the use of vapor phase systems; develop improved sizing agents that have lowered BOD and CO requirements; develop textile finishing procedures that reduce energy requirements concurrent with reduced pollution; utilize textile wastes as a media for biomass production, substitute less energy intensive unit operations for those currently used; expand the research to commercialize the boric acid vapor phase process to impart smolder resistance to cotton batting and upholstery fabrics; extend the vapor phase boric acid process to cellulosic insulation.

c. Investigate the feasibility and effectiveness of combining one or more unit processes, such as scouring, bleaching, dyeing, finishing (for durable press, water repellancy, soil release, flame retardance, tec.) to eliminate one or more drying operations; develop processes for the finishing of cotton that can be effectively and efficiently carried out at room temperature; substitute vapor phase processes for those utilizing aqueous media or alternatively use solvent systems that have lower specific heat and latent heat of vaporization than water; develop new procedures for the wet processing of cotton fabrics involving a minimum of water during the processing and a minimum remaining with the fabric upon completion of the operation.

d. Develop new and radically different methods for drying in-process liquids that do not wet cotton; ultrasonic, microwave, infrared or ultraviolet radiation for conventional hot air drying; develop new finishing systems that retain lower amounts of water and that release water more readily than present-day cotton fabrics; and develop new padding techniques including transfer methods that minimize the amount of water retained by the fabric after treatment.

e. Establish the operations which consume the greatest amounts of energy per unit of febric and investigate the possible recovery of low-grade energy suitable for use in heating working areas or water for processing; and capitalize upon energy release from exothermic chemical reactions used in finishing cotton-containing textiles.

f. Mechanical, physico-chemical and enzymatic procedures of combinations thereof will be investigated as means of removal of lint and linters from cottonseed; the milling of non-delinted cottonseed will be investigated for its potential; the effects of changes in de-lintering upon the quality of the oil, meal, and fiber fractions of the seed will be evaluated; and the effect of de-lintering procedure upon energy consumption will be determined.

g. Linters may also be reduced by genetic selection. Research on the inheritance of various linter patterns on the seed is needed to increase the effectiveness of selection in breeding programs. Research is also needed on the effect of various linter patterns on seed loss during harvesting and energy consumption for the delintering process.

h. Conserve heat energy by chemically modifying cotton textiles with agents and by processing methods that operate at ambient or only slightly elevated temperatures. Decrease energy needed for drying and curing in chemical finishing by application of agents by minimum add-on techniques such as loop application, transfer padding, vacuum padding, spraying, coating, and the like. Optimize conditions for these application methods and integrate them into finishing schemes for cotton textile materials.

i. Develop suitable processes for the heat transfer printing of cotton which make possible durable, brilliant, multi-color prints on the fabric by transfer from paper and thus avoid the high-energy consumption of conventional printing.

j. Develop and utilize activated catalyst systems for low energy-consuming, non-polluting durable-press, and other chemical processing. Acquire increased understanding of catalyst mechanisms for more efficient textile finishing. Employ finishing agents with suitable leaving-groups for autocatalysis and for synergistic activation of commonly used catalysts. Conduct finishing treatments at lower temperatures and/or shorter processing times to decrease necessary energy inputs. Establish minimum processing time-temperature relationships to produce the desired functional properties in cotton textile materials.

II - CONSERVATION OF SOIL AND WATER THROUGH WISE MANAGEMENT OF NATURAL RESOURCES IN PRODUCTION AND PROCESSING

SPECIFIC RESEARCH ACTIVITIES

A. Cultural, Tillage, and Pest Management Practices for Improved Soil Properties, Crop Production, and Reduced Runoff to Comply With PL 500, Sec. 208

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	0.1	0.1	0.2	102
	0.1	0.0	0.1	105
	0.0	0.2	0.2	307
	1.0	0.1	1.1	308
	0.0	0.1	0.1	309
No Increase	0.9	0.1	1.0	308
	0.0	0.1	0.1	309
20% Increase	1.0	0.1	1.1	308
	0.0	0.1	0.1	309
Recommended	0.7	0.3	1.0	207
	0.7	0.3	1.0	208
	0.7	0.3	1.0	209
	3.0	1.0	4.0	308

2. Priority: 1

3. Situation: Adverse physical and chemical conditions in the soil reduce cotton yield and fiber quality across the Cotton Belt. It is not known which soils or under which conditions these soils respond to mechanical disruption or to perforation by root systems of other species. New systems that limit traffic to zones or lanes, or systems that use soil amendments to improve structure and water relations need to be devised and evaluated. Studies on the use of organic wastes need to be expanded. The wastes improve structure, reduce compaction, improve fertility, and improve soil-plant-water-air relations.

   Recent work indicates that organic materials may be used to move Ca into acid subsoils. Conditions under which this system may be used need to be defined.

   The Clean Water Act (PL 500, Sec. 208) is going to have a major impact on cultural practices used in producing cotton. New systems that reduce runoff and erosion must be devised, i.e.,

forms of reduced tillage, multiple cropping, rotations, and no-till. Residue management research will be needed as well as research on the attendant disease and insect problems. These systems must be developed under constraints of low energy inputs.

4A. Objective: Develop methods for improving unfavorable soil physical and chemical conditions. (Priority 1)

5A. Research Approaches (in order of priority):

a. Develop procedures for disrupting physical barriers to root growth by biological or mechanical means.

b. Identify chemical or organic soil amendments to improve soil properties.

c. Develop controlled traffic patterns for minimizing compaction.

d. Improve techniques for correcting subsoil acidity.

e. Determine which soils respond to profile modification.

4B. Objective: Develop production systems that minimize water and wind erosion for environmental protection and sustained production. (Priority 2)

5B. Research Approaches (in order of priority):

a. Devise crop rotations and double cropping systems for reducing soil and water losses.

b. Develop row patterns, bed shapes, and tillage systems to reduce soil losses.

c. Develop minimum tillage systems.

4C. Objective: Define interactions between cultural practices and pest management systems for economic crop production. (Priority 3)

5C. Research Approaches (in order of priority):

a. Develop short-season production systems.

b. Identify the relationship between canopy microclimate and pest dynamics.

c. Integration of conservation tillage systems with pest management.

B. Water and Energy Conservation Through Improved Irrigation Scheduling, Fertilizer Technology, and Growth Regulator Use

1. SY Situation:

Support level	Number of SY's			RPA distribution
	SEA-AR	SAES	Total	
Current	0.0	0.5	0.5	307
No Increase	0.0	0.5	0.5	307
20% Increase	0.0	0.6	0.6	307
Recommended	0.7	0.3	1.0	105
	0.3	0.2	0.5	103
	1.7	0.8	2.5	106
	3.3	1.7	5.0	307
	1.3	0.7	2.0	309

2. Priority: 2

3. Situation: Cotton requires water delivered by irrigation systems at intervals through 65 to 85 percent of the growing season in the irrigated western United States. Successive drought periods during the growing season are causing increased attention to irrigation as a possible economically feasible supplement to rainfall in subhumid areas of Southeast. Though water is a significant production cost, its regulation through proper scheduling provides a unique opportunity to control plant growth and development that favors high productivity. With high costs, limited availability of energy, and increasing competition for the available water supply, irrigation managers must obtain the greatest possible yield for water and energy resources used in production. An understanding of the interacting effects of water, fertilizers, climate, and growth regulatory substances on new and existing plant genotypes can lead to management and increased water use efficiency. Results from these studies will permit the control of plant canopies for increased photosynthesis efficiency, and insect control. Major changes in production systems such as short-season, narrow row cultural practices and stripper harvesting have been limited because of adverse harvesting conditions that occur with excessive plant growth that is a product of fertile soils, rainfall, and irrigation.

4A. Objective: To develop techniques for scheduling irrigations that consider variability in soil water retention characteristics, stage of plant development, evaporative demand, and salinity hazard. (Priority 2)

5A. <u>Research Approaches</u> (in order of priority):

a. Develop irrigation scheduling indices that incorporate level and duration of water deficit, stage of plant development, and prior water deficit conditioning.

b. Identify soil-plant-microclimate parameters and generate base data for irrigation scheduling.

c. Identify interrelations of genotype and plant water status.

d. Develop irrigation schedules that are optimum for plant growth and diminish salinity hazards for sustained crop production.

e. Investigate the interaction of water and nitrogen as production inputs.

4B. <u>Objective</u>: To develop economically feasible irrigation methods for improved uniformity of water distribution, decreased water loss, and reduced energy consumption. (Priority 1)

5B. <u>Research Approaches</u> (in order of priority):

a. Develop innovative system designs for achieving this objective.

b. Develop improved cultural approaches for maximizing utilization of both available rainfall and irrigation water.

c. Develop improved procedures for using irrigation systems for the application of nutrients and pesticides.

4C. <u>Objective</u>: To control plant canopy development for increased photosynthetic and water use efficiency. (Priority 1)

5C. <u>Research Approaches</u> (in order of priority):

a. Alteration of canopy geometry by the use of different genotypes, planting patterns, and physical or chemical means for increased energy transfer and gaseous exchange.

b. Investigate the use of growth regulating substances for altering plant growth, fruiting habit, and boll maturation.

4D. <u>Objective</u>: Determine the nutritional needs of the cotton plant for sustained or increased production. (Priority 2)

5D. <u>Research Approaches</u> (in order of priority):

a. Investigate the interrelationships of nutrition and water use efficiency.

C. Develop Cultivars for Improved Efficiency Under Environmental Stress[1/]

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	0.0	0.0	0.0	--
No Increase	0.0	0.1	0.1	102
	0.1	0.0	0.1	105
	0.0	0.2	0.2	307
20% Increase	0.0	0.1	0.1	102
	0.1	0.0	0.1	105
	0.0	0.2	0.2	307
Recommended	0.7	0.3	1.0	102
	0.7	0.3	1.0	103
	2.7	1.3	4.0	105
	2.7	1.3	4.0	307

2. Priority: 3

3. Situation: Conservation can be improved with cultivars which make better use of water and nutrients under limiting conditions. Adversities of soil and climate limit crop yields. Cyclic variations in weather create major fluctuations in farm income, regional prosperity, and consumer prices. No crop or agricultural region is free from these problems. The situation is understood and appreciated widely yet there is a lack of research leading to scientific understanding about the complex ways plants interact with their environment under stress. This knowledge is needed to provide a scientific basis for the development of new stress-tolerant cultivars and to improve the stress tolerance of present cultivars by chemical or cultural methods. In cotton, as in other crops, conventional breeding approaches to improve stress-tolerance have been exploited. An extensive collection of *Gossypium* germplasm is available and should be screened for adaptive, stress-tolerant traits as these become identified through research. Techniques for producing interspecific hybrids need to be developed. Heritability of new traits needs to be established. New breeding methods may need to be developed to incorporate desirable traits into commercial germplasm. Such genetic advances are permanent and cumulative. In addition, promising new growth regulating chemicals and antitranspirants are available and should be evaluated on cotton under environmental stress.

4A. Objective: Evaluate physiologic and morphologic traits to identify mechanisms associated with adaptation to stress. (Priority 1)

1/ Also see Research Opportunities for Environmental Stress.

5A. Research Approaches (in order of priority):

a. Evaluate exotic accessions and cultivars of cotton for traits which confer earliness, water-use efficiency, drought tolerance, cold tolerance, and salinity tolerance.

b. Alter adaptation of current cultivars by antitranspirants and with chemical and physical means for inducing earliness or drought, cold, or salinity tolerance.

4B. Objective: Develop improved breeding stocks and cultivars. Priority 2.

5B. Research Approaches (in order of priority):

a. Develop physio-genetic techniques for breeding under environmental stress.

b. Convert promising exotic accessions of cotton to day-neutral flowering.

D. Improved Soil and Water Resource Management for Crop Production Efficiency Through Modeling and System Simulation

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	0.2	0.0	0.2	309
No Increase	0.2	0.0	0.2	309
20% Increase	0.2	0.0	0.2	309
Recommended	0.3	0.2	0.5	105
	0.3	0.2	0.5	307
	0.7	0.3	1.0	309

2. Priority: 4

3. Situation: Considerable efforts have been directed toward developing basic physiological models for understanding the growth and development of the cotton plant. These models are valuable in highlighting specific areas where additional fundamental data regarding soil-water-atmosphere-plant relationships are needed for improved understanding of the total system. Results from the in-depth plant system models provide insights for developing simplified models which can be used as practical decision-making tools. Particular emphasis is needed in this latter area in future modeling and system simulation research.

4. Objective: Develop and utilize models for improving the efficiency of production inputs. Priority 1.

5. Research Approaches (in order of priority):

   a. Develop simplified models for use as practical management tools.

   b. Use of models to quantify the effects of planting configuration, tillage, growth regulators, fertilization, etc., on plant performance (growth and yield).

   c. Interface growth and pest management models.

   d. Develop and use models for improving the timing and amounts of production inputs.

   e. Use models for economic analyses of various management practices.

   f. Use remote sensing and ancillary data (weather, soil maps, etc.) inputs to agrophysiological models.

III - CONSERVATION OF CHEMICALS

SPECIFIC RESEARCH ACTIVITIES

A. Chemical Conservation in the Processing of Cotton Lint and Seed

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	1.3	0.0	1.3	407
No Increase	1.0	0.0	1.0	407
20% Increase	1.0	0.0	1.0	407
Recommended	1.0	0.0	1.0	407

2. Priority: 6

3. Situation: Competition between industries in developing improved end products from natural and synthetic fibers is an important factor in insuring that consumers obtain economical and acceptable finished goods. Improved functional properties such as flame resistance, durable press, and water repellancy are characteristics that are necessary if cotton is to remain competitive. Greater efficiencies in the application of chemicals in cotton processing will reduce cost and environmental pollution. Opportunities for greater efficiencies in the application of chemicals to cotton exist in improvement of conventional treatment methods and in new treatment approaches including free radical processing and vapor phase treatments. Cottonseed is processed into crude oil, meal, hulls, and linters. These processing operations use large amounts of chemicals and will be required to meet OSHA and EPA regulations.

4. Objective: Improve efficiency of chemical utilization in the processing of cotton and cottonseed products.

5. Research Approaches (in order of priority):

   a. Investigate energetics and mechanisms of free-radical reactions in preparation of flame resistant, durable press cotton by electron spin resonance spectroscopy. Compare effects of chemical modifications and finishing processes of cottons by free-radical reactions of cotton, initiated by thermal, high-energy, and photochemical radiations. Develop finishing processes based upon ultraviolet treatments for cotton and high cotton content blend fabrics which produce valuable functional properties such as

improved resiliency, printing and dyeing receptivity, soil release, and water repellancy. Acquire information on chemical modification of cotton by photofinishing processes.

b. Develop techniques which allow low amounts of solution to be uniformly dispersed in fabric so that resin migration is reduced, more uniform crosslinking distribution with less resin requirement occurs, and less energy is needed for drying and curing.

c. Develop new water-repellant systems for outdoor cotton fabrics that are improved and more durable to weathering. Employ metal salt complexes, polymer emulsions, waxes, silicones, silanes, and modifications of these agents to produce water repellancy for awnings, tents, canopies, boat covers and other cotton fabrics that are durable under the rigors of natural weather conditions.

d. Establish engineering specifications for borate ester vapor phase treatment of cotton batting. Evaluate the data obtained to determine the most effective conditions of processing in terms of uniformity of add-on of boric acid and the amount needed to pass the Mattress Flammability Standard. Design a vapor generator and recovery system to improve chemical usage; control vapor composition, residence time in reactor, initial water content of the fibers, vapor velocity and direction of flow, vapor and reactor temperature.

e. Apply chemical engineering principles, including mathematical modelling, to the problems of THP-type flame retardant textile finishing. Modify or develop equipment and operating techniques for optimizing the processes. Verify the results by pilot plant experimentation and prepare engineering specifications to enhance commercialization.

f. Acquire knowledge of abiotic nitrogen fixation. Study electrochemistry of the reduction of triplet state molecular oxygen to superoxide anions, their stabilization in aprotic media, and their role as a reducing agent. Emphasize metal-organic lignin complexes similar to those of metal ions essential to electron transport in living systems and their roles in the oxidation-reduction reactions of nitrogen and oxygen containing compounds.

g. Develop ecologically and economically acceptable processes that reduce the amounts of chemicals used in delinting seed, seed cleaning, hull removal, and separation of oil and protein.

B. Production Efficiency and New Cultural Systems to Conserve Chemicals

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	0.2	0.1	0.3	308
	0.0	0.1	0.1	309
No Increase	0.3	0.1	0.4	308
20% Increase	0.3	0.1	0.4	308
	0.0	0.1	0.1	309
Recommended	0.5	0.1	0.6	307
	0.5	0.2	0.7	308
	0.0	0.2	0.2	309

2. Priority: 2

3. Situation: Improving cultural systems and management efficiency could result in conservation of chemicals. For example, reducing the fruiting season could result in a reduced number of insecticide applications. On the other hand, more judicious use of chemicals, even within conventional cultural practices, could possibly reduce the chemical use per unit of seed and fiber output.

4. Objective: To reduce the amount of chemicals used in cotton production through improved cultural systems.

5. Research Approaches (in order of priority):

   a. Reduce chemical use by improving the fruiting pattern of cotton plants by means of controlled rate and timing of production inputs.

   b. Develop cultural systems that require fewer field operations.

   c. Develop varieties and cultural systems for optimum utilization of production inputs, including fertilizer and pesticides.

   d. Improve the efficiency of chemical inputs by optimizing plant spacing patterns.

   e. Develop cultural systems which utilize cover crops to conserve soil and fix available nitrogen.

   f. Accelerate development of cotton plant canopy to shade and suppress further weed growth.

C. Precise Application of Agricultural Pesticides - Conventional Equipment

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	0.0	0.1	0.1	207
	0.0	0.1	0.1	208
	0.0	0.3	0.3	209
	0.0	0.1	0.1	307
	0.0	0.1	0.1	308
No Increase	0.1	0.0	0.1	207
	0.0	0.1	0.1	208
	0.1	0.1	0.2	209
	0.0	0.0	0.0	307
	0.1	0.1	0.2	308
20% Increase	0.1	0.0	0.1	207
	0.0	0.1	0.1	208
	0.1	0.1	0.2	209
	0.0	0.0	0.0	307
	0.1	0.1	0.2	308
Recommended	0.1	0.0	0.1	207
	0.0	0.1	0.1	208
	0.1	0.1	0.2	209
	0.0	0.0	0.0	307
	0.6	0.6	1.2	308

2. Priority: 4

3. Situation: The high cost of pesticides and the national concern over conserving energy and reducing the level of contamination of the environment with chemicals has focused attention upon the improved use of pesticides in cotton production. About 80 percent of the pesticides used in cotton production are currently applied with spray equipment. Because of the nature of this equipment, much of the chemical fails to reach the target. Problems arise from spray drift, application inefficiency, chemical ineffectiveness, safety hazards, and nonuniform application rate.

4. Objective: To improve conventional application equipment and techniques to allow pesticides to be applied at the lowest effective rate with minimum escape to the environment.

5. Research Approaches (in order of priority):

   a. Improve application equipment by incorporation of monitoring and feedback controls to apply chemicals to soil and plant at optimum rates.

   b. Develop chemical application guidelines based upon meteorological conditions that allow pesticides to be safely applied with minimum drift.

   c. Improve equipment and application techniques for chemicals used in conservation tillage systems.

   d. Combine improved chemical application equipment and mechanical cultivation techniques to allow band width of post-emergence herbicides to be reduced.

   e. Improve granular application equipment to accomplish accurate placement and optimum mixing with soil.

D. Precise Application of Agricultural Pesticides - New Techniques

1. SY Situation:

	Number of SY's			RPA
Support level	SEA-AR	SAES	Total	distribution
Current	0.0	0.6	0.6	207
	0.7	0.0	0.7	209
	0.0	0.8	0.8	308
No Increase	0.1	0.5	0.6	207
	0.7	0.0	0.7	209
	0.0	0.8	0.8	308
20% Increase	0.5	0.2	0.7	207
	0.6	0.2	0.8	209
	0.8	0.4	1.2	308
Recommended	0.5	0.2	0.7	207
	0.1	0.0	0.1	208
	0.6	0.2	0.8	209
	1.3	1.0	2.3	308

2. Priority: 1

3. Situation: Some studies have shown that 70 to 80 percent of the pesticides applied with the conventional spray systems do not reach the target. This low efficiency and associated safety hazards dictate a reevaluation of pesticide application methodology. New formulations of pesticides and biological control agents also require new application equipment or major changes in existing systems.

4. Objective: To reduce the rate of pesticide application by developing new application methodology and techniques.

5. Research Approaches (in order of priority):

   a. To develop an electrostatic spray system that will provide optimum deposition of the chemical to the target.

   b. To determine the relationship of deposited spray droplet size to pest control efficiency.

   c. To develop equipment for application of slow release formulation of chemicals.

   d. To develop equipment for application of biological control agents.

E. Fertilizer Conservation

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	0.0	0.3	0.3	307
No Increase	0.0	0.3	0.3	307
20% Increase	0.0	0.4	0.4	307
Recommended	0.8	0.3	1.1	307

2. Priority: 3

3. Situation: The major factor influencing the recommended fertilizer rates for cotton production has been yield. Production of chemical fertilizers requires high inputs of natural gas and was among the first inputs in cotton production to feel the effect of the energy crisis. Also, fertilizer contributes to nonpoint source pollution.

4. Objective: To reduce the amount of fertilizer per unit of production by increasing the efficiency of application, increasing plant utilization and by reducing fertilizer loss to air and ground water.

5. Research Approaches (in order of priority):

   a. Develop technology to maximize the effectiveness of time and rate of fertilizer application through tissue analysis and other monitoring techniques.

   b. Document a complete nutrient inventory of our soils as a basis for future recommendation of nutrient needs.

c. Develop technology to maximize efficiency of fertilizer uptake and utilization.

d. Determine effect of pesticides (especially layby heribicides) on nutrient uptake.

e. Develop equipment and techniques for proper placement of fertilizers.

f. Improve efficiency of natural fixation of nitrogen.

F. Simulation Models to Optimize Pest Control

1. SY Situation:

	Number of SY's			RPA
Support level	SEA-AR	SAES	Total	distribution
Current	0.0	0.0	0.0	207
	0.0	0.1	0.1	209
	0.1	0.1	0.2	307
	0.1	0.1	0.2	308
	0.3	0.0	0.3	309
No Increase	0.1	0.0	0.1	207
	0.1	0.1	0.2	209
	0.1	0.1	0.2	307
	0.1	0.1	0.2	308
	0.1	0.0	0.1	309
20% Increase	0.1	0.0	0.1	207
	0.1	0.1	0.2	209
	0.1	0.1	0.2	307
	0.1	0.1	0.2	308
	0.1	0.0	0.1	309
Recommended	0.2	0.0	0.2	207
	0.2	0.0	0.2	209
	0.0	0.1	0.1	307
	0.5	0.1	0.6	308
	0.1	0.0	0.1	309

2. Priority: 5

3. Situation: Dynamic modeling of plant growth and pest populations hold significant promise for improved scheduling of pesticide applications. Proper scheduling can result in maximum benefits from pesticides and biological agents.

4. Objective: To optimize pest control through the use of simulation models.

5. <u>Research Approaches</u> (in order of priority):

   a. Utilize existing models for cotton plant development and pest population dynamics to evaluate alternative control strategies for periodic pest management decisions.

   b. Improve plant growth and pest dynamics models.

   c. Develop simulations for the interaction of cotton plants, pests and chemicals, and use these models for production decisions.

RESEARCH OPPORTUNITIES
ENVIRONMENTAL QUALITY

SITUATION

Several activities related to the production, processing, and manufacture of cotton give rise to substances that are real or potential pollutants of the environment. These substances may be sediments, the unused portion of chemicals applied intentionally, or by-products of essential processes in the cotton industry. Processing and manufacturing wastes include dusts from ginning and milling operations, natural constituents of cotton such as waxes and oils that must be removed, and dyes and other chemicals used during manufacture.

In recent years, some effort has been devoted to understanding the effects of such pollutants and to developing methods for reducing or eliminating their occurrence and distribution in the environment. However, many problems remain, particularly in the area of water pollution arising from cotton production and manufacturing practices. Also, there is a need to develop more efficient materials handling and collection systems to reduce air and noise pollution levels and improve working conditions in cotton gins and finishing plants to conform to State and Federal regulations.

Federal legislation (PL 92-500) has been enacted to implement control of water pollution by nonpoint agricultural pollutants, i.e., sediment, pesticides, and plant nutrients from farmlands. Impending legal restrictions on the amounts of soil erosion and sediment and chemical content in runoff from cotton lands will be extremely difficult to meet with current technology. Regulations relative to air and stream pollution arising from textile plants will likewise be difficult to meet and may accelerate the shift to synthetic fibers.

The cottonseed oil milling industry is faced with compliance with an Occupational Safety and Health Administration Cotton Dust Standard, promulgated in 1978, which states that the industry must decrease the level of dust in the working environment to 0.5 mg/m^3, as measured by a vertical elutriator, by September 8, 1982, utilizing engineering controls.

The current research effort on environmental quality that is related directly to cotton is small, but considerable work on drift of pesticides, movement of pesticides and plant nutrients in soil, sediment, and water, residual phytotoxicity of herbicides, and the behavior and fate of organic chemicals, in general, is applicable to cotton as well as other crops. Other research of a general nature on dust movement may also be related, in part, to cotton. In particular, attention is called to research on dust (air pollution) in textile mills and cotton gins. Because the dust problem is associated with

certain worker-health problems in textile mills, the health aspects of the research effort in this area is covered by the section on Health and Safety in this report.

The number of SY's currently identified with environmental quality and with cotton is 5.2. This effort is assigned mainly to: (a) sediment-water-chemical transport from cotton lands; (b) pesticide drift and methods of reducing and controlling it; (c) phytotoxicity of residual herbicides in crop rotations; (d) developing procedures, equipment, and treatments in cotton gins to reduce air pollution; and (e) developing processes and treatments for reducing air and stream pollution arising from textile plants. The knowledge obtained from this research will help to develop soil and water management practices and manufacturing processes that maintain or improve environmental conditions while ensuring food and fiber production at minimum costs.

The Subcommittee on Environmental Quality identified three subtopics for discussion and evaluation: (a) Environmental pollution from cotton production; (b) control of environmental pollution in and around cotton gins and cottonseed oil mills; and (c) control of environmental pollution in and around textile mills.

To a great extent, the level of research on environmental quality will be dictated by the administration of regulations by Federal and State agencies relative to air and stream pollution and by concerns for the safety, health, and quality of the environment as related to workers and the public. Any new pollution-related problem in a vital area could necessitate a sharp increase in pollution-related research.

SPECIFIC RESEARCH ACTIVITIES

A. Environmental Pollution from Cotton Production

1. SY Situation:

Support level	Number of SY's			RPA
	SEA-AR	SAES	Total	distribution
Current	0.0	0.4	0.4	207
	0.0	0.1	0.1	307
	1.1	0.0	1.1	308
	0.5	0.5	1.0	901
No Increase	0.0	0.4	0.4	207
	0.0	0.1	0.1	307
	1.1	0.0	1.1	308
	0.5	0.5	1.0	901
20% Increase	0.0	0.1	0.1	207
	0.0	0.1	0.1	307
	1.1	0.0	1.1	308
	0.5	1.0	1.5	901
	0.3	0.0	0.3	107
Recommended	0.0	0.1	0.1	207
	0.0	0.1	0.1	307
	1.1	0.0	1.1	308
	2.2	0.7	2.9	901
	1.5	0.0	1.5	107

2. Priority: 1

3. Situation: Cotton production requires tillage and chemical-use practices that leave the land exposed as a potential water pollution source. Sediment and farm chemicals transported by runoff from cotton lands have been implicated as a source of water pollution. Sediment as a physical entity impairs the quality of water in which it is transported and can be a carrier of other pollutants such as farm chemicals. Farm chemicals (pesticides and plant nutrients) can have deleterious effects in aquatic areas that receive agricultural runoff. Additionally, pesticides may drift into nontarget areas during application, enter the atmosphere by volatilization during and after application, and can affect and/or contaminate succeeding crops because of persistence and residual activity in soil.

   Legislation (PL 92-500) to control water pollution by nonpoint agricultural pollutants requires (Section 304) that information be provided on (a) guidelines for identifying and evaluating the nature and extent of nonpoint sources of pollutions, and (b) processes, procedures, and methods to control pollution resulting from agricultural activities. The legislation further requires (Section 208) that each State plan and implement programs to achieve water quality goals by decreasing both point and nonpoint pollution. The Best Management Practices concept, including soil and water conservation practices, will be used to control both point and nonpoint pollution sources. However, little information is available on the effectiveness of soil and water conservation practices in controlling chemical transport from croplands. Impending legal restrictions on the amounts of soil erosion and sediment and chemical content in runoff from cotton lands will be extremely difficult to meet using current technology. For example, allowable tolerance limits of 5 tons/acre/year for erosion may be established. Soil loss in the Mississippi Delta averaged 7 tons/acre/year on cotton lands formed to 0.2 percent slope.

   In the Mississippi Delta, cotton land receives intensive treatment: 2 to 5 herbicide applications, 1 or 2 fertilizer applications, as many as 8 tillage operations, and 5 to 15 insecticide applications. Most of the herbicide and fertilizer application and tillage operations occur during a time when little vegetative cover exists and the soil is subject to the erosive forces of rainfall and runoff. Insecticides are applied primarily during the summer months, a period of high intensity thunderstorm activity. Thus, these cultural practices leave cotton subject (1) to erosion with subsequent sediment and chemical transport in runoff during the tillage period, February through May, and (2) to insecticide washoff from the cotton plants with transport in runoff during August and September. The partitioning of chemicals between sediment and water in transport is a function of the concentrations and physical and chemical properties of the chemical and sediments. In general, the more water insoluble chemicals, e.g., organochlorine pesticides and phosphorus, are transported primarily by sediments,

and their concentrations and yields in runoff are closely related to sediment concentrations and yields. The concentrations and yields in runoff of the more water soluble chemicals, e.g., methyl parathion and nitrate nitrogen are primarily functions of the probability of rainfall and runoff occurring shortly after application. Basic research is needed to define (1) insecticide concentrations in washoff from the cotton canopy as functions of rainfall intensity and volume and elapsed time after application, and (2) the mode of transport (partitioning between sediment and water) in subsequent runoff.

The magnitude, frequency distribution, and significance of sediment and chemical yields from cotton lands are not well defined. Further, the effectiveness of soil and water conservation practices (terraces, grassed waterways, cover crops, reduced tillage, etc.) in decreasing the concentrations and yields of both sediments and chemicals in runoff, and their effects on pesticide persistence and carryover to succeeding crops need additional research.

An increase in sediment-farm chemical control regulations will probably accompany the implementation of nonpoint control programs developed under Section 208. Mathematical models will be used by regulatory agencies to predict the movement of water, sediment, and agricultural chemicals from farmlands. Information on hydrology, erosion, sediment transport and deposition; pesticide drift, volatility, and washoff from plants, chemical disappearance; and sediment-water-chemical interactions is needed to develop reliable predictive models. Instrumented research plots and watersheds together with rainfall simulation studies will provide the necessary input data for model development, testing, and verification.

4. Objectives:

a. Define the magnitude of sediment and agricultural chemical losses (yields) from cotton lands under current cultural practices, and evaluate various Best Management Practices, including soil and water conservation practices, for controlling sediment and farm chemical yields from cotton lands. Priority 1.

b. Define the role of sediment in farm chemical transport from cotton lands, i.e., the partitioning of chemicals between sediment and water in runoff. Priority 2.

c. Obtain the necessary input data for sediment-water-chemical model development, testing, and verification; improve soil loss prediction of the Universal Soil Loss Equation (USLE) on cotton lands with slopes less than 3 percent; and develop a procedure using sediment delivery ratios to predict sediment yield from field-size watersheds. Priority 3.

d. Minimize contamination of nontarget areas caused by drift of pesticides from treated fields. Priority 4.

e. Determine the effect of rainfall amount and intensity, and the effect of time interval between pesticide application and rainfall, on the amount of pesticide washed off cotton plants and the mode of transport in subsequent runoff. Priority 5.

f. Define the magnitude of fertilizer, crop canopy, and crop residue inputs of plant nutrients and relate to the temporal and spatial distribution of measured nutrient concentrations in runoff and sediment from cotton lands. Priority 6.

g. Evaluate the hazard from carryover of pesticide residues in cropping systems involving cotton, Priority 7.

5. Research Approaches: The research approach will be experimentally-based using instrumented plots and watersheds, rainfall simulation, and controlled laboratory studies to:

a. Measure storm sediment and chemical yields in runoff from Mississippi cotton lands, and evaluate reduced tillage practices and structural runoff controls, e.g., parallel tile outlet terraces, for reducing farm chemical and sediment concentrations and yields in runoff. Priority 1.

b. Define the mode of chemical transport and determine chemical partition coefficients between sediment and water in runoff. Priority 2.

c. Measure drift of pesticides from sprayed fields, especially in relation to new pest management practices, new application techniques, and new pesticides, and evaluate the hazard to nontarget species of animals and plants inhabiting affected areas. Priority 3.

d. Evaluate the effect of rainfall amount and intensity on the amount of farm chemicals washed off cotton plants. Priority 4.

e. Evaluate the effect of time interval between pesticide application and rainfall on the amount of pesticide washed off plants. Priority 5.

f. Evaluate the persistence and carryover in soil from one season to the next of new pesticides introduced into cotton production; determine the phytotoxicity of new herbicides used in rotations which include cotton. Priority 6.

B. Control of Environmental Quality in Cotton Gins and Cottonseed Oil Mills

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	1.5	0.0	1.5	308
	0.2	0.0	0.2	709
No Increase	1.5	0.0	1.5	308
	0.2	0.0	0.2	709
20% Increase	1.8	0.0	1.8	308
	0.3	0.0	0.3	709
Recommended	6.7	0.0	6.7	308
	0.5	0.0	0.5	709

2. Priority: 3

3. Situation: This subject is interrelated with Research Problem Area No. IX, Health and Safety, and the discussion and proposals in that area should be consulted. The environmental quality problem in cotton gins and cottonseed oil mills is characterized by exterior air pollution from pneumatic materials handling and control systems, in-plant air contamination, and high noise levels in some areas of the processing plants. Research is being conducted on all of these subjects, and control devices and techniques that meet State and Federal regulations and standards have been developed. However, additional research is needed to refine and improve the available control equipment as more stringent regulations and standards are promulgated by regulatory agencies, and new regulatory standards are adopted.

Materials handling systems in cotton gins and cotton oil mills depend heavily upon pneumatic conveying systems. Pneumatic conveying systems characteristically consume large quantities of energy, cause high noise and dust levels with work environments, and present problems complying with community air pollution regulations. Development of mechanical systems for materials handling will provide multiple benefits of reducing community air pollution, lower noise and dust levels in the work environments, and decrease energy consumption.

With respect to environmental quality in cottonseed oil mills, other areas that interact with this research are approaches c and d in Section B (Control of Mycotoxins in Cottonseed Products) of the subcommittee report on Health and Safety and Approach V in Section B (Changes in Harvesting, Ginning and Milling Related to Cottonseed Quality) of the subcommittee report on Seed Quality, Processing, and End Us.

4. Objectives:

   a. Develop economically feasible engineering control systems for existing cotton gins and cottonseed oil mills that will allow industry to meet the new OSHA cotton dust standards. Priority 1.

   b. Develop materials handling and foreign matter collection systems for cotton gins and cottonseed oil mills that (1) meet new environmental standards for air quality and noise, and (2) are more efficient from an energy utilization standpoint. Priority 2.

5. Research Approaches:

   a. Develop economically feasible ventilation systems for existing cotton gins and cottonseed oil mills designed to meet the new OSHA cotton dust standards. Priority 1.

   b. Develop an environmentally sound heat recovery system from gin trash incinerators to provide an alternate source of energy for the fossil fuel requirement for seed cotton drying prior to ginning. Priority 2.

   c. Develop noise control devices and engineering modifications of ginning and oil seed processing equipment to reduce noise levels in gins and oil mills in anticipation of regulatory standards for workers' health and safety that will require industry compliance. Priority 3.

   d. Develop more efficient materials handling and collection systems to reduce air and noise pollution levels and improve working conditions in the processing plant to conform to State and Federal regulations at minimum cost. Priority 4.

   e. Conduct engineering feasibility studies of methods to: (1) reduce or eliminate pneumatic conveying and conveying ducts, (2) apply the monoflow air system to reduce final air exhaust volumes, and (3) eliminate machinery components such as separators. Prototype feasible designs for experimental study. Priority 5.

   f. Develop methods to replace conventional positive pressure pneumatic lint and linters doffing and handling from the gin stand and saw linters through lint cleaning to the bale press. Priority 6.

   g. Determine if a cyclone can be an effective secondary air cleaner for a cyclone. Determine if a cyclone can be a practical primary cleaner for lint-condenser exhausts. Priority 7.

C. Control of Environmental Quality in and Around Textile Mills

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	0.6	0.0	0.6	407
	0.1	0.0	0.1	709
	0.2	0.0	0.2	901
No Increase	0.6	0.0	0.6	407
	0.1	0.0	0.1	709
	0.2	0.0	0.2	901
20% Increase	0.6	0.0	0.6	407
	0.0	0.0	0.0	501
	0.2	0.0	0.2	709
	0.3	0.0	0.3	901
Recommended	0.9	0.0	0.9	407
	0.1	0.0	0.1	501
	1.5	0.0	1.5	709
	2.5	0.0	2.5	901

2. Priority: 2

3. Situation: This subject is interrelated with health and safety, and reference to the proposals in that area should be consulted. At present, there are two major problems that relate to both environmental quality and health. First is the dust problem in opening, carding, and spinning, which subsequently leads into the byssinosis health problem. The chemicals present in the textile mill environment constitute the second item.

   Formaldehyde vapors are a paramount concern because formaldehyde is present in every resin finish used to make cotton or cotton blends smooth drying and shrink resistant. The universal need for a fabric to be so processed means that any problem associated with resin finishing would be a major concern, should formaldehyde exposure become a recognized hazard. Although a number of other chemicals are present in the textile mill environment, the complex aromatic character of many dye types makes them possible problems in any stepped-up testing relative to potential carcinogenic or mutagenic activity. While other chemicals likewise may raise problems, they are not as widely employed as formaldehyde-containing agents or dyestuffs.

   There is also the problem associated with water pollution from textile mills. Desizing and dye wastes and sundry other chemicals are the principal problems. To a great extent, the amount of research required will be controlled by the lower limits on stream pollutants set by the Environmental Protection Agency. Should some of these limits be set to the point where

they necessitate curtailment of currently used processes, extensive research for either alternative processes or recovery of waste chemicals may be dictated.

It is important to recognize that problems associated with dust and formaldehyde and certain water pollution problems are cotton problems rather than mill problems per se, for textile mills have the option of switching to blend levels containing a higher polyester component. Such a switch would immediately alleviate the mill problem, but it would have a harmful impact on cotton consumption.

Two other areas associated with the environment in textile mills should likewise be considered. First, most finishing involves evaporization of copious quantities of water and heating of fabrics at elevated temperatures. As such, attainment of a reasonable comfortable work environment is difficult and expensive. Second, the noise associated with looms is greater than anticipated allowable decibels levels. As such, some method is desirable to lower noise level in weaving rooms containing a large number of looms.

4. <u>Objectives</u>:

   a. Develop efficient finishing systems that reduce vapors and other chemicals evolved in finishing. Priority 1.

   b. Reduce the level of stream pollutants produced by textile mills. Priority 2.

   c. Develop systems that lower the amount of moisture removed from fabric by evaporization during processing and thus lead to lower water consumption and reduced humidity in mill environment. Priority 3.

   d. Modify production equipment for cotton-containing textiles to minimize and abate the noise level. Priority 4.

   e. Reduce the amount of heat evolved or required in normal finishing operations. Priority 5.

5. <u>Research Approaches</u>:

   a. Prepare and evaluate formaldehyde-free crosslinking agents as a means of reducing formaldehyde evolved in finishing and garment plants. Priority 1A.

   b. Reduce the amount of formaldehyde evolved by formaldehyde-containing agents by modification of current systems. Priority 1B.

c. Replace solvent-based polymeric coating systems for outdoor fabrics with systems based on aqueous emulsions. Priority 1C.

d. Modify THPOH-NH_3 finish to reduce vapors from formaldehyde- and phosphorus-containing compounds. Priority 1D.

e. Devise more efficient dyeing and finishing processes, which produce lower quantities of disposable waste materials. Priority 2A.

f. Devise feasible methods for removing and possibly recovering textile chemicals from mill waste waters based on chemical separation techniques or biological filtration systems. Priority 2B.

g. Devise feasible methods for padding wet fabrics and for reducing the amount of moisture to be removed in the drying of padded fabrics. Investigate transfer pad, febric loop, transfer printing, and vacuum impregnation techniques for this purpose. Priority 3.

h. Determine the most economical methods of complying with Federal and State regulations relating to environment and employee safety and provide engineering specifications for modifications needed for textile processing equipment with regard to noise level. Priority 4A.

i. Develop new equipment for textile processing that would minimize ambient noise in mill environment. Priority 4B.

j. Develop finishing systems based on low-temperature catalysts or vinyl-type polymerizations as a means of reducing mill ambient temperatures. Priority 5.

RESEARCH OPPORTUNITIES
HEALTH AND SAFETY

SITUATION

Basic and applied research aimed at developing techniques and systems that will "improve human health and safety" have become high priority items in our rapidly changing agricultural world. Research to determine the agents in cotton dust that cause byssinosis and to deactivate and/or eliminate them as well as research to reduce dust levels by engineering controls is crucial to solving a haunting problem which spans the entire cotton industry from farmer to textile manufacturer. According to the Occupational Safety and Health Administration (OSHA) processing and handling of cotton and cottonseed products can cause acute reactions in susceptible individuals. Research to insure cottonseed products that are free from inherent toxic residues or toxins occurring by contamination and to develop methods for the detection and control of pathogens, toxins and chemical residues in cotton and cottonseed products are equally important areas of concern. Flammability standards imposed by governmental agencies have created an urgent need for research to improve safety and health features of cotton fabrics and upholstery materials acceptable to the consumers. Active legislation at the National and State levels has focused attention on textile processing as a major source of some potentially hazardous chemical emissions and environmental pollution; innovative research in identification, control and elimination of pollution from the wet processing of cotton must be vigorously supported.

An important element in a meaningful "health and safety" research program, is a close working relationship with those Federal agencies concerned with controlling toxicity (acute and chronic) of chemical substances that can be inhaled, ingested or absorbed through the skin. The Occupational Safety and Health Administration (OSHA) concerned with the working environment (including air emissions, water, solid waste); the Consumer Products Safety Commission (CPSC) concerned with the safety of consumer products, and the Food and Drug Administration (FDA) concerned with food for both human and animal consumption--all of these agencies have a need for the cooperation and research information developed by SEA, SAES, and University research scientists in the area of toxicity of substances and its control.

The worthwhile goal to continue improvement in the health and safety of the American people can be attained only with an active research program which recognizes the needs of the public, the cotton farmer, and the workers in all the industrial sectors involved. There is a need for a comprehensive research program designed to supply information on all aspects of cotton and cottonseed processing which can be integrated into products and processes which offer minimum hazard to all involved in production and use.

SPECIFIC RESEARCH ACTIVITIES

A. Elimination of the Causative Agents of Byssinosis and Control of Cotton Dust.

1. SY Situation:

Support level	Number of SY's SEA-AR	SAES	Total	RPA distribution
Current	11.2	0.2	11.4	709
No Increase	18.3	0.2	18.5	709
20% Increase	27.8	0.2	28.0	709
Recommended	27.8	0.2	28.0	709

2. Priority: 1

3. Situation: Byssinosis is an occupational respiratory disease which can be induced in susceptible individuals (reactors), by the long-term inhalation of "cotton-related" and other fiber dusts. In the initial stages of the disease, which usually become evident after about 10 years of exposure, afflicted individuals begin to suffer from chest tightness and shortness of breath following the return to work after a weekend or any respite of 48 hours or more from work. In later stages, which normally develop after many years of exposure, the afflicted individual suffers from loss of respiratory capacity and may become disabled (i.e., develop a condition indistinguishable from chronic bronchitis).

Until the causative agents contained for example in cotton dust are isolated and their effects verified with rigorous epidemiological testing, the potential hazard to cotton workers from "lint-free respirable cotton dust"[1/] must be controlled, even without a complete understanding of the etiology of byssinosis. OSHA maintains that worker protection from exposure to cotton dust can be assured by controlling lint-free respirable cotton dust, below a prescribed permissable exposure limit (PEL). The standard provides that no employee in the textile industry shall be exposed to greater than 200 ugm/m^3 of lint-free respirable cotton dust in all areas of the mill except in slashing and weaving where the limit is 750 ugm/m^3. In all other industries where employees are exposed to cotton dust, except gins, the limit is 500 ugm/m^3 (including knitting). The measurement is averaged over an 8-hour work shift. For gins, OSHA did not specify a PEL but did require that gins meet most of the other provisions of the general industry standards.

1/ Defined by OSHA as dust present in the air during the handling or processing of cotton, of approximately 15 microns or less aerodynamic equivalent diameter, as measured by vertical elutriator.

Cotton dust contains mineral particles, pieces of plant tissue and micro-organisms in addition to lint and fuzz fragments of fibers. As yet, no single substance has been unequivocally demonstrated as being the cause of byssinosis and the pathogenesis of byssinosis is still unknown. Recent work has suggested a variety of suspect causatives; bacterial endotoxins, plant pigments, aminopolysaccharide(s), and others. A research program is urgently needed to identify specifically the causative agents of byssinosis and to effect their elimination or deactivation.

Recently, researchers at the USDA Southern Regional Research Center have developed new and efficient equipment for capturing and removing respirable cotton dust from the textile mill environment. At the USDA Clemson facility, researchers have demonstrated the successful use of oil additives to minimize dust levels. These recent developments and the explicit exemption for "washed cotton" in the final OSHA cotton dust standard have led to a reordering of research priorities. "Washed cotton" research has accelerated since it is viewed by many in government and industry as a near-term alternative to costly, conventional ventilation and filtration systems, as well as the medical surveillance and record keeping required by the standard. Other longer term alternatives being considered include the deactivation of the causative agent in cotton dust by gaseous treatments - which would preclude costly and energy intensive drying - and unopened boll harvesting of cotton - which would ideally allow delivery of a cotton free of byssinogenic activity to the mill.

4. Objective: Reduce or eliminate, by economically and ecologically acceptable processes, the health hazards associated with converting cotton fibers into finished textile products through:

    a. Development of means for elimination, inactivation, prevention, or destruction of causative factors. Priority 1.

    b. Identification of possible causative factors of byssinosis. Priority 2.

    c. Evaluation of available or new methods (bioassays) for detecting byssinosis causatives. Priority 3.

    d. Development of systems to measure, control, and minimize dust emission in mill operations that do not require massive air-energy-intensive handling systems. Priority 4.

5. Research Approaches:

   a. Clean cotton by selected liquid (washed cotton) and vapor phase treatments to deactivate or eliminate the causatives of byssinosis. Priority 1.

   b. Separate and identify possible causatives of byssinosis in respirable cotton dust. Priority 2.

   c. Assay cotton dusts from unopened boll harvested cotton by chemical and biological means to determine byssinogenic activity. Priority 3.

   d. Examine and identify byssinogenic materials using immunochemical techniques. Priority 4.

   e. Assay cotton dusts chemically and biologically for byssinogenic activity. Priority 5.

   f. Incorporate dust suppression equipment in conventional textile processing machinery without decreasing quality or production rate. Priority 6.

   g. Develop processing technology employing electrostatic, magnetic, and aerodynamic forces for the handling of cotton fibers to minimize dust emission in the textile mill environment. Priority 7.

   h. Test the validity of histamine release as a primary mediator in byssinosis and as an assay system for the causative of byssinosis. Priority 8.

   i. Determine lung macrophage responses as related to the causative agent of byssinosis. Priority 9.

   j. Develop a totally enclosed automated system for processing cotton fibers into yarn in a continuous fashion, performing the tasks of opening, cleaning, tuft forming, fiber separation and alignment, and conveyance to the spinning unit. Priority 10.

   k. Differentiate cotton-related dust materials by elemental analysis. Priority 11.

   l. Investigate combination of antihistamines as detoxifiers for the causatives of byssinosis. Priority 12.

B. Identification, Control and Elimination of Mycotoxins and Environmental Contaminants in Cottonseed Products

1. SY Situation:

Support level	Number of SY's			RPA distribution
	SEA-AR	SAES	Total	
Current	6.2	2.2	8.4	702
No Increase	6.2	2.2	8.4	702
20% Increase	7.4	2.6	10.0	702
Recommended	7.4	2.6	10.0	702

2. Priority: 2

3. Situation: Surveys have established that a serious problem of aflatoxin contamination exists in cottonseed grown in Arizona and the Imperial Valley of California. Recently (August 1978) aflatoxin M_1 has been detected above the level permitted by FDA in retail store milk from cows fed aflatoxin contaminated cottonseed meal in the State of Arizona. No producing area in the Cotton Belt is free from the possible occurrence of aflatoxin in cottonseed and its products. The major portion of the aflatoxin in contaminated seed appears in the meal. At levels above 20 parts per billion (ppb), the meal cannot be marketed for domestic feed.

A process has been developed at SRRC, in cooperation with WRRC and the cottonseed industry, to inactivate aflatoxins in cottonseed meal by treatment with anhydrous ammonia. Interim approval was granted by FDA for use of 1972 crop ammonia detoxified cottonseed meal (ADCM) for cattle feeding and for limited feeding to laying hens, and a petition to FDA is now pending to allow acceptability of ADCM. However, extensive feeding tests will be required to establish and insure animal and human safety. The feeding tests on this process have been concluded and the histological evaluation of the tissues from hens fed the decontaminated meals is in progress. Despite the technological success of the SRRC process, it is limited by the fact that it is a batch type operation. This precludes widespread use by industry which might require large quantities of meal over short-time intervals. The process should be made a continuous process to insure sufficient output of decontaminated meal. A further need exists to decontaminate the whole seed.

Successful research on improved methodology for mycotoxin detection, rapid determination of levels and on elimination of mycotoxins in cottonseed products would safeguard their food and feed markets, maintain farm income, strengthen export markets, and improve the balance of payments.

The possibility exists, as a result of environmental conditions, agricultural practices, storage, processing, and packaging and handling operations used with cotton and cottonseed, that food and feedstuffs from cottonseed could be contaminated with toxic, antinutritional, or disease-producing materials. A need exists for knowledge of potential contaminants and methods for prevention or elimination. The urgency of this need is evident in the present emphasis on food use of cottonseed protein products.

The development of new agricultural practices for cotton must be evaluated not only in terms of the effect on production but also in terms of translocation of constituents to the seed and changes in seed composition. Inherent in such a problem is the need for suitable analytical methodology and methods of elimination.

Recent directives from OSHA and EPA will bring about significant changes in oil mill processing operations. Through proper attention to design and choice of equipment, the need to meet OSHA and EPA standards and the need to produce a cottonseed product with an acceptable microbial profile could both be met. Pathogenic organisms such as salmonellae, staphylococci, *Clostridium prefrigens* or *Cl. botulinum* could be introduced into cottonseed and its products at any step of production from harvesting, to processing, to packaging. Cultures of *Alternaria longipes*, *A. alternata*, and *A. tenuissima* isolated from cottonseed and bolls have been shown to be toxigenic, when cultured on various laboratory media. Some of these *Alternaria* may be a factor in acute responses of people exposed to cotton dust. Operations must be designed to take full advantage of innate microbial kill steps in cottonseed processing to prevent recontamination. To ensure reasonable shelf life in refrigerated, frozen and partially precooked convenience foods, there is a need to reduce accepted levels of microbial population in commodities even further. Physical and chemical methods used to attain these low microbial levels must not produce carcinogenic or toxic derivatives or affect the physical, functional, and nutritive characteristics of the product.

4. Objectives:

a. Develop simple, accurate, and rapid methods to detect mycotoxin contamination in cottonseed and cottonseed products. Priority 1.

b. Develop technology to eliminate or inactivate microbiological and environmental contaminants in food and feed products. Priority 2.

c. Devise sensitive and accurate quantitative methods for determining mycotoxin in cottonseed products, feeds containing cottonseed meal, and in milk, eggs, and edible tissues from animals fed contaminated cottonseed materials. Priority 3.

d. Develop procedures and conditions for processing plants to deter proliferation of mycotoxin-producing fungi. Priority 4.

e. Develop technology to eliminate or inactivate mycotoxins in contaminated cottonseed products and establish safety of these processes to meet FDA requirements. Priority 5.

5. <u>Research Approaches:</u>

a. Develop accurate and rapid techniques to detect and quantify mycotoxins in cottonseed. Priority 1.

b. Develop continuous detoxification process suitable for commercial application to inactivate mycotoxins or remove them from cottonseed and cottonseed meal. Priority 2.

c. Develop equipment for cleaning, delintering, cracking, and dehulling of cottonseed kernels to reduce airborne contaminants. Priority 3.

d. Improve methods of air filtration and conveyance systems adaptable to oil mill operations to reduce contamination and minimize recontamination. Priority 4.

e. Devise methods for assaying allergenic potential of *Alternaria* spores and develop methods for their elimination. Priority 5.

f. Devise methods for sterilization of cottonseed by-products, such as hulls and seed fractions, which are returned to the meal as diluents, to prevent recontamination with salmonellae or other pathogens. Priority 6.

g. Determine enzymes produced by strains of *A. flavus* cultured under nutritional stress conditions to induce, and to attenuate mycotoxin production. Correlate specific enzymes with production of mycotoxins. Priority 7.

h. Determine if treatments with chemicals such as herbicides, insecticides, defoliants, rodenticides, desiccants, and plant growth regulators result in biologically active residues in the seed and food and feed products, and devise techniques for their elimination. Priority 8.

C. Improved Flame Retardance and Smolder Resistance for Cotton End-Use Products

1. SY Situation:

Support level	Number of SY's			RPA distribution
	SEA-AR	SAES	Total	
Current	34.4	0.8	35.2	709
No increase	27.3	0.8	28.1	709
20% Decrease	27.5	0.6	28.1	709
Recommended	27.5	0.6	28.1	709

2. Priority: 3

3. Situation: Except for certain high risk categories, efforts to market voluntarily flame retardant (FR) apparel have proved to be unsuccessful. Apparently consumers are generally unwilling to pay voluntarily for the insurance provided by flame retardant cotton products, and retailers have been reluctant to market many of them.

The imposition of flammability standards to provide for the safety of children's nightwear has resulted in an almost complete loss of market for cotton even though durable flame retardant treatments and technology are available.

Research to minimize the flammability of cotton was initiated in the USDA shortly after the end of World War II to supply a military need. This USDA research is the foundation on which most present knowledge and industrial technology is based. Cellulose burns in two different modes, by flaming combustion, or by glowing or smoldering combustion. The mechanism for preventing flaming combustion, which is a rapid oxidation of degradation products that takes place in the gaseous phase, is by chemically changing the course of the reaction so that more solid char and less volatiles are formed. The mechanism for preventing smoldering combustion, which is a slow oxidation of solid material, found most practical is through a coating of the fibers with glass like compounds which inhibit chemisorption of oxygen.

For apparel and certain household fabrics the performance of textile products is based upon open flame testing with the fabric held in a vertical position. The THPOH/NH_3 process developed at USDA's Southern Regional Research Center yields cotton products that do not ignite or support combustion. In addition the properly finished fabric has excellent strength retention, good hand, and durability to multiple home launderings. The products do not withstand chlorine bleaching, the costs are high, and additional finishing is required to impart easy care characteristics.

The recent Consumer Product Safety Commission action in connection with the use of tris (2, 3-dibromopropyl) phosphate (referred to as Tris) which was employed as a flame retardant for fabrics made from man-made fibers has had an adverse effect upon the use of THPOH in the form of guilt by association (all flame retardants are presumed to be health hazards).

The test criteria for mattresses and upholstered furniture are lighted cigarettes. Under such conditions cotton filling material or fabrics combust via a smoldering mode. Research over the past 10 years has shown that the most effective compound to render cotton fibers resistant to ignition by cigarettes and from smoldering combustion is boric acid. As a result of this research, a new vapor phase process for the impregnation of cotton and other cellulosic fibers with boric acid has been developed. The process conserves energy since it is applied at room temperature, and no drying or curing with heat is needed. The process works on cotton batting, cotton containing upholstery fabrics, and on cellulosic insulation made from recycled newsprint.

Currently, upholstery fabric is backcoated to improve dimensional stability and wearing quality of the textile, therefore, the development of backcoating system based on smolder inhibiting polymeric materials appears to be a practical approach to the problem. For recreational and camping uses, it is imperative that cotton containing textiles not only be flame retardant initially but be durable upon exposure to outdoor conditions.

CPSC is considering a mandatory standard for upholstery furniture and is still concerned about a more rigid general wearing apparel standard. The furniture industry has developed a voluntary action plan and a one-year trial period for its use is expected to be approved by CPSC in late 1979.

There are indications that the next generation of standards will attempt to regulate the emissions from combusting apparel and household goods to minimize toxicity. Such considerations will require new concepts of treatment, new compounds to treat with, a better knowledge of what happens during combustion, and what compounds are produced under what conditions.

Most of the effective flame retardants for cotton are based upon phosphorus chemistry. Effluents from processing, gasses produced during drying and curing of treated fabrics, and the evolution of chemicals such as formaldehyde may present health hazards. New NIOSH and OSHA regulations on worker safety and health will require that considerable research effort be expended to establish the magnitude of the problems and to devise means of modifying procedures and formulations to minimize the production of odorous and possibly harmful chemicals.

4. <u>Objectives:</u>

a. Develop or modify phosphorus containing flame retardants to enhance their resistance to chlorine bleaching during

laundering; improve the performance of phosphorus containing flame retardants by combining them with organosulfur, nitrogen, organohalogen, and/or metal oxides; develop new non-phosphorus flame retardants based on organohalogen compounds; develop finishes durable to outdoor weathering for recreational uses. Priority 1.

b. Identify the products of combustion and possible toxicity hazards that result from the burning of flame retardant treated cotton; elucidate the mechanisms of flame and smolder resistance; determine the effects of contaminants including pesticide residues on flammability; evaluate proposed test methods to ascertain their applicability and their ability to rate fairly the flammability hazard of textile products. Priority 2.

c. Develop processes to impart smolder resistance to mattresses and upholstered furniture to minimize the hazard posed by these products. Priority 3.

d. Develop FR fabrics having durable press and other desirable end-use properties. Priority 4.

e. Develop new flame retardance and durable press finishes for cotton with reduced release of formaldehyde and/or phosphorus compounds during processing; develop new techniques for curing such as ultraviolet light; minimize the potential for the production of possible hazardous compounds; synthesize and evaluate new compounds that may be substituted for those currently in use; seek systems for flame retardance that take advantage of a synergistic effect between chemicals. Priority 5.

5. Research Approaches:

a. Prepare flame retardants of the tetrakis (hydroxymethyl) phosphonium (THP) type; develop new flame retardants not based on THP-type systems; improve resistance of FR treated products to chlorine bleach and to outdoor weathering. Priority 1.

b. Conduct basic research employing sophisticated instrumental analyses to improve chemical reactions and systems to impart durable flame retardance. Priority 2.

c. Develop chemical formulations, finishing systems, engineering specifications and equipment for vapor phase, padding, backcoating and other methods for treating cotton containing textile products to obtain smolder resistance sufficient to comply with existing and proposed flammability standards. Priority 3.

d. Develop durable press cotton containing fabrics that are also flame retardant; improve the strength and abrasion

resistance of flame retardant and crosslinked cotton fabrics; modify the chemical and physical properties of cotton by altering its crystalline structure; utilize emulsion polymers in place of crosslinking chemical systems. Priority 4.

e. Establish engineering specifications for THP-type flame retardant processes by use of mathematical modeling and other modern chemical engineering techniques to enhance commercialization; reduce or eliminate odorous or potentially hazardous gaseous emissions; use new techniques to supply energy to achieve polymerization and/or chemical modification for improved flame retardant products. Priority 5.

D. Identification, Control and Elimination of Pollution from the Wet Processing of Cotton

1. SY Situation:

	Number of SY's			RPA
Support level	SEA-AR	SAES	Total	distribution
Current	1.6	0.2	1.8	901
No Increase	1.6	0.2	1.8	901
20% Increase	1.9	0.2	2.1	901
Recommended	1.9	0.2	2.1	901

2. Priority: 4

3. Situation: The Clean Water Act of 1966 focused national attention on textile processing as a major source of environmental pollution. The industry uses about 135 billion gallons of water annually, and is surpassed by only the chemical, paper, and food industries in biochemical oxygen demand (BOD) of the effluents discharged. Further complications result since the industry is concentrated in a few Southeast, mid-Atlantic, and New England States.

The translation of cotton from bale to marketable fabric involves a multiplicity of both mechanical and chemical processing. Chemical processing includes sizing, desizing, scouring, bleaching, mercerizing, fulling, dyeing, printing, resin treatments to impart water repellancy, soil repellancy, flame retardance, durable press, etc., all requiring large amounts of water. Desizing, scouring and mercerization operations result in the generation of large quantities of alkaline water, high in BOD. The water used in finishing operations is "contaminated" with resins and chemicals which should be removed before discharge. The Environmental Protection Agency (EPA) has established a timetable for the reduction of discharge from industrial processing by 1985.

The chemical finishing of textiles results in the generation of noxious gases, irritants, and other airborne pollutants. The environment of the worker within the confines of the mill, the finishing plant, and the garment plant, is becoming increasingly important to the industry as a result of stricter OSHA standards on noise and exposure to potentially hazardous chemicals. Reduction of noise levels from processing machinery is currently one of the most urgent problems, but it appears to be a general textile problem common to all fibers rather than specific to cotton (except in ginning and cottonseed oil mills). However, exposure to chemicals in one form or another during processing is more often associated with finishing cotton and other natural fibers than with synthetics. NIOSH has initiated studies on several chemicals present in industrial atmospheres and OSHA has set standards for worker protection applicable to processing and manufacturing. Research is needed to establish whether methods by which these pollutants are analyzed are valid and produce results that correlate with actual practice. Redesign of equipment and processes to reduce worker exposure, and substitution of less hazardous chemicals and finishes wherever possible must be a continuing part of any research program.

Most all of wet processing operations require hot water. Not only are the processes very energy intensive, but also contribute significantly to thermal pollution of local streams and rivers.

4. <u>Objectives:</u>

   a. Develop new and/or modified chemical systems, equipment, and procedures for processing cotton-containing textiles to eliminate potential pollutants to water and air at their source.

   b. Reduce worker exposure to potentially hazardous chemicals.

   c. Substitute less hazardous chemicals and finishes wherever possible.

   d. Evaluate chemical separation and recovery techniques to permit reuse of chemical additives, dyes, resins, and process water.

   e. Investigate and develop techniques for treating existing textile waste streams for recovery of pollutants and their subsequent reuse as sources of nutrients, feed, or energy.

5. <u>Research Approaches:</u>

   a. Develop chemical separation techniques to textile effluent streams that not only reduce pollution but also permit the reuse of finishing chemicals, dyes, and process water. Priority 1.

b. Further develop mechanical techniques for removing water from fabric for subsequent reuse. Mechanical removal of water also reduces the drying effort resulting in fewer plant emissions and reduced energy usage. Priority 2.

c. Develop methods of cleaning textile effluent streams through the use of natural biological filtration systems, i.e., water hyacinths, duckweed, and other water plants, that are known to scavange nutrients, heavy metals, and other pollutants from eutrophic lakes. Priority 3.

d. Develop non-hazardous finishing systems based on chemicals other than formaldehyde, formaldehyde derivatives and modify formaldehyde containing systems in order to comply with regulatory standards designed to reduce formaldehyde exposure in the working environment as well as to the consumer. Priority 4.

e. Investigate and develop methods for improving the transport phenomena between liquid and fabric, thus requiring less process liquids, decreased processing temperatures and times. Priority 5.

f. Develop new chemical systems for size applications that will minimize BOD levels in effluent streams and permit desizing with ambient temperature water. Such a system not only reduces BOD loadings, but also results in less thermal pollution along with subsequent energy savings. Priority 6.

g. Develop a method for the ammonia scouring of cotton which will avoid the use of sodium hydroxide with attendant water polluting potential. Priority 7.

h. Establish whether existing tests for assessing formaldehyde evolution in industrial and home atmosphere adequately reflect actual hazardous conditions. Priority 8.

i. Develop systems for the chemical processing and finishing of cotton textiles which employ solvents other than water. Priority 9.

j. Evaluate the acute and chronic toxicity of compounds used as flame retardants in cotton and of potentially hazardous gaseous emissions. Priority 10.

b. Further develop mechanical techniques for removing water from [illegible] for subsequent [illegible]. Mechanical removal of water also reduces the drying effort resulting in fewer [illegible] emissions and reduces energy usage. Priority 2.

c. Develop methods of removing [illegible] effluent streams through the use of natural biological filtration systems, i.e., water hyacinths, duckweed, and other aqua plants that are known to remove nutrients, heavy metals and other pollutants from wastewater flows. Priority 3.

d. Develop non-hazardous finishing systems based on chemicals other than formaldehyde, [illegible] derivatives and readily [illegible] controlling systems in order to comply with regulatory standards designed to reduce formaldehyde exposure in the working environment as well as to the consumer. Priority 4.

e. Investigate and develop methods for improving mass transfer phenomena between fibers and chemicals, and recycling [illegible] process liquids. [illegible] processing [illegible] and [illegible] Priority 5.

f. Develop new chemical systems for [illegible] applications that will minimize and reduce the effluent streams and [illegible] associated with ambient temperature water. Such a system not only reduces BOD loadings, but also [illegible] to less thermal pollution along with subsequent energy savings. Priority 6.

g. Develop a method for the [illegible] scouring of [illegible] which will avoid the use of sodium hydroxide and [illegible] water-polluting [illegible]. Priority 7.

h. Establish whether existing tests and [illegible] evolution in industrial and home [illegible] reflect actual hazardous conditions. Priority 8.

i. Develop systems for the [illegible] of [illegible] finishing of cotton textiles which employ [illegible] water. Priority 9.

j. Evaluate the acute and chronic [illegible] tests as these relate to [illegible] hazardous [illegible] emissions. Priority 10.